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THE PRESENT SITUATION IN RUBBER

By Gustave Heinsohn

THE price of crude india-rubber, which of late has advanced to an unprecedentedly high level, is a matter of concern not alone to the manufacturers of rubber goods; it touches the pocketbooks of the consumers of such goods, whose name is legion and who are scattered in every country on the globe. For it must be considered that practically all civilized persons to-day require, in some shape or other, more or less rubber in connection either with some business or industry or their personal convenience or comfort.

The growth in the use of rubber—a practically valueless commodity prior to the discovery of the process of "vulcanization" less than seventy years ago—has been unique in industrial history. Not that the quantity of the material has become so large, in comparison with some others which serve as bases of manufacturing. It must be kept in mind, however, that the use of the principal metals, textile materials, leather, and so on, antedates history, whereas there are men now living who were doing important work in the world before Charles Goodyear patented his vulcanizing process.

It is probable that no other commodity ever came into such varied use within so short a period as india-rubber. First employed practically for footwear and other waterproof apparel, rubber has come to be employed in electrical insulation, hose pipes for the conveyance of water, steam, air, and so on; pneumatic and other tires for all sorts of wheeled vehicles, balloons and the planes of aerial machines, innumerable articles for the comfort of invalids, household conveniences, and what not. A point of interest in this connection is that, thus far, rubber has never come into use to an important extent for any given purpose to which it is not still devoted; in other words, its advantages are so marked in many uses that, when once introduced, no substitute can be found for it.

These considerations help to explain the present high cost of india-rubber. More than twelve shillings, or three dollars, lately has been paid per pound for rubber in important quantities, and the best informed opinion in the market is that a lower level of prices is not to be looked for in the near future. What such a price means is better understood when it is mentioned that the best rubber cost only one-fifth as much twenty years ago, while up to 1855 rubber was at times a drug in the market at not over a shilling a pound. Of course, all rubber does not fetch the

same price. The market custom is to quote the highest grades, it being understood that when these realize any given figure lower grades may be expected to cost relatively lower prices for differences in quality commonly understood.

It will readily be understood that at times the consumption of rubber exceeds the world's production. Such was the case during the last year, for which complete statistics are available. Of course, there exist at all times stocks of rubber of various grades scattered through the markets of the United States and Europe, not to mention the primary markets of the tropical rubber-producing countries; and it seldom happens that it is impossible for a manufacturer to obtain any grade of rubber desired so long as he is able to pay the price demanded. But it may be said with accuracy to-day that the production of rubber is falling behind the consumption.

The rubber goods manufacturer does not first take account of the stocks of raw material and plan his operations accordingly. On the contrary, he considers the orders placed with him for goods and buys the raw material necessary for filling the orders. One of the most important factors in putting up the cost of crude rubber in recent years has been the rapid growth of the automobile industry. While it is true that the ingenuity of the pneumatic tire inventors and builders has been the basis of the increase in automobiling, the increased demand for rubber has come more directly from the makers of motor cars than from the makers of tires. The rubber manufacturers, however, do not want to be found wanting, and in their efforts to supply the ever-rising demand for tires they buy rubber at whatever cost and turn it into equipment for motor wheels.

Rubber is unique also in the respect that, whereas its place has been established among the world's necessities—and no longer among its luxuries merely—and whereas its production and consumption grow steadily, its cost as steadily advances. Most other commodities have declined in price in the face of increased demand and an established rate of consumption. It is necessary to refer only to steel as an illustration. The difference is to be found in that rubber is a natural product, brought into a serviceable condition by hand labour in tropical regions unsuited for residence by any people yet known as civilized.

Not the least remarkable fact in connection with the output of rubber is that so many pounds of the material come out of the Amazon valley annually, gathered by the constant application of the work of ignorant natives, cutting into the bark of the trees day after day, with the gain from such trees daily of a few teaspoonfuls of latex, which, by the laborious "curing" process, yields perhaps half of its volume in the rubber of commerce. In other rubber countries the yield per man's work is smaller and the money value less, since no other rubber is comparable to that obtained from the Amazon species of trees.

Here it may be mentioned that commercial rubber is derived from no less than 300 or 400 species, as classified by botanists, scattered throughout the world's equatorial belt. Most of these species are not persistent in their yield, so that many regions in Africa colonized by European Powers, once opened up to the production of rubber with promising results, have gradually declined in yield. This has been true, for example, of the Congo Free State, the rubber interest of which has been discussed so widely. Already the merchants reputed to have profited so largely from rubber under the former régime on the Congo are diverting their investments to other regions, as now offering larger returns from rubber. It is recognized that the world's chief reliance for rubber is upon the Hevea species,

native to the Amazon valley, the trees of which may be "tapped" perennially, with an undiminished yield, and the product known commercially as "Para" rubber, from the port of that name, realizes a permanently higher price. Para rubber, by the way, is the only grade that can be used in the better classes of goods, such as tire inner tubes, rubber threads, elastic bands, first-grade rubber footwear, and many other articles. Cheaper rubber enters into garden hose, door mats and rubber goods in general in which elasticity, for one thing, is not a requisite.

The rubber trees in the Amazon region, scattered among dense forests over an area nearly as large as the United States, are accessible only during part of the year, owing to the annual rise in the rivers. For the most part, there is no settled population in these regions, and such population as does exist is extremely sparse. The climatic and hygienic conditions have been most unfavourable for the introduction of other labourers than natives of tropical South America, and those do not increase rapidly. It may be said that the labour conditions alone have been sufficient to prevent the supply of Para rubber from reaching a rate comparable with the world's demands. Yet the situation is not hopeless. Nearly forty years ago the British Colonial Office, through the agency of the Kew Gardens, introduced specimens of the Hevea rubber tree from the Amazon into the Far East, with the result that it has become acclimatized, particularly in Ceylon and the Federated Malay States. The local botanical gardens having demonstrated the practicability of cultivating this rubber in regions where rubber is not indigenous, planters of tea, cocoa, and the like, have taken up the new crop enthusiastically, and with unexpectedly good results. During the past year nearly 10,000,000 pounds of plantation rubber was exported from Ceylon and Malaya at prices higher than were realized for any other rubber in the world, for the reason that it was marketed in a cleaner condition than the "forest" rubber shipped from Para.

The favourable results from Hevea in the British East Indies led to experiments in planting the same species in the Dutch East Indies and in many of the European colonies in Africa. From many of these plantations rubber is received regularly in the markets of Europe and the United States. Manufacturers show a preference for the new type of rubber, and the extreme high prices reported nowadays in the daily press relate to the product of plantations. The financial results attained by some of the planters have attracted widespread attention, dividends as high as 100 per cent. having been paid by some of the first companies formed; but these doubtless were capitalized very conservatively.

The rapid increase in the rate of yield of rubber plantations already productive and the extensive new planting which such results have encouraged have led to the expression of fears of over-production within the next decade or sooner. In respect of such fear it may be suggested that—

1. All the plantations formed to date can hardly be expected to realize such results as in the case of the best that have been reported.

2. A considerable part of the plantation product is required annually to offset the falling off in forest rubber in various colonies in Africa and elsewhere.

3. There is no prospect of a decline in the consumption of rubber; on the contrary, a vastly larger demand is reasonably to be expected.

There remains to be considered a new régime on the Amazon—the home of Hevea rubber. Hitherto the normal conditions of rubber gathering in the hinterland of Para has been work on a small scale by innumerable independent operators—but not independent financially. These

were furnished with food and other supplies by provisioners at the mouth of the Amazon, who had a first lien on any rubber produced. The small operators referred to sent their collections of rubber downstream whenever a chance opportunity offered, and it was sold by the provisioner to whom consigned at whatever the day's price might be. There was little system involved except that a condition of indebtedness was general. In view of the risks involved, every middleman had to figure on large book profits, and in very many cases these were the only profits realized in the business.

Gradually a new condition has come about in South America, due in no small degree to the successful planting in Ceylon of Hevea rubber—a variety of which the Brazilians once believed themselves to hold a monopoly. But, in view of the competition of the Far East now recognized, the necessity for better business conditions on the Amazon is now seen, and of supplying rubber to consumers at lower prices than were thought possible formerly. The larger profits in Ceylon, by the way, are due to the fact that the "market" for rubber is still made by the Amazon product, which is eight or more times as large as the Eastern plantation output. As the plantations yield more, and at a minimum of cost, due to scientific management, it is the hope of the planters that they can sell to consumers at a good profit, but at figures which would spell loss on the Amazon.

Whatever in reality may be the situation as between Ceylon and Amazon, an awakening has occurred in the latter region, embracing governments, merchants, financiers, shipping interests and the newspapers, as well as the rubber handlers, and already definite results are in prospect.

The new normal condition on the Amazon will embrace:

1. The ownership in fee simple of large rubber-producing areas, whereas formerly such ownership did not exist.

2. The operation on a large scale of rubber collection by the land owners, with ample capital, who will "provision" their own camps without the aid of middlemen.

3. The clearing out of forests and the planting of rubber between the Hevea trees already standing and productive, just as virgin jungle in the East is cleared and planted to rubber.

4. The transportation of supplies up and down the streams by means of boats owned by the rubber proprietors.

5. The exportation by the producers of their own rubber, possibly to consumers in Europe and North America.

6. Arrangements whereby branches of State banks will finance such operations as have been outlined above—something not provided for by law in the past. Recently the Brazilian banks have begun to make advances on rubber in storage.

To sum up: There is little prospect of more forest rubber being produced as a whole, though here and there a new district may be opened and for a while yield liberally, offsetting a decline in production in a new colony. Meanwhile, the world will constantly demand more rubber. One hope for the consumers is based upon the introduction of rubber cultivation in the Far East. The people of the Amazon have accepted the challenge of the East, and in the competition of the Old World and the New in the supplying of Hevea rubber consumers of this grade may ultimately obtain more regular supplies, in better condition, and at much lower prices; but all of this will take time.

The development of the world's rubber industry is best illustrated by the volume of production of the raw material, for the reason that at no time has the production largely exceeded the immediate consumption. To take the Amazon region alone, the official figures of production for

the different years stated have been:

Year	Tons	Year	Tons
1827	31	1875	7,730
1836	156	1880	8,679
1845	561	1885	11,782
1850	1,469	1890	15,355
1855	2,197	1895	19,310
1860	2,672	1900	26,748
1865	3,546	1905	35,393
1870	6,602	1909	39,452

For a long time the production of other than Amazon rubbers was negligible, but finally it equaled the amount exported from Para, and then the output of forest rubber other than Hevea began to decline, though the figures for some other countries are unofficial. A recent approximate estimate of the sources of rubber from a reputable source is as follows:

	Tons
The Amazon River	39,000
Other Brazilian sources	2,800
Mexico and Central America	1,500
Africa	18,800
Asia (other than plantations)	1,200
Plantation rubber	4,600
Total	67,900

The absolute stocks of rubber in the world at any time, outside the hands of manufacturers, cannot be stated; but the best authorities of late years have reported them lower than formerly. Thus, a leading London firm lately reported the total visible supply at only 5,000 tons, as against 8,000 tons one year previously, and to-day the figures are believed to be lower than 5,000 tons.

And now may be introduced the estimates, by a leading Antwerp firm, of the world's production and consumption of rubber in tons:

Year	Production	Consumption
1895	34,277	33,952
1897	39,890	38,719
1899	49,790	48,251
1901	51,892	50,490
1903	55,948	54,195
1905	69,507	65,727
1907	68,646	64,528
1909	69,372	70,075

In every comment upon such figures it must be considered that, unlike metals, the tendency of rubber is to shrink in weight from the hour of production, and that no cargo of rubber ever yet crossed the sea without a heavy loss in avoirdupois. A thousand tons may be the accurate weight of a cargo of rubber in the country of production; what it may show on the scales in the consuming countries is a different question.

Note. — The preceding statistics state only what has become recognized as standard grades of rubber. In recent years some gums of a lower standard have appeared in the market from different countries, which are available in the rubber factories, and which are likely to be improved to an extent which will entitle them to figure in the statistics of rubber; but to include them at this time would confuse the study of rubber statistics on any basis now customary. Some such gums are marketed at prices as low as eight cents a pound, and the total production in this class is probably 20,000 tons a year.

THE FIGHTING POWER OF BATTLESHIPS

By Archibald S. Hurd

SINCE the British battleship *Dreadnought,* embodying the all-big-gun principle, was designed and the familiar auxiliary armament was abandoned, an old controversy has been revived as to the fighting power of battleships of various nationalities, for there are very important variations in design between the ships building, for instance, for the British fleet and those under construction for Germany and between those on the stocks in the United States and the contemporary vessels of Japan.

There is a tendency to judge the power of a ship by the amount of metal which can be thrown if all the guns were fired simultaneously and without regard to whether they could be brought to bear upon an enemy or could be fired as fast in war as they can be fired in theory—on paper. This method of judging a ship of war is somewhat analogous to the cannibal's idea of effective music. To an untutored savage the most effective piano would be one in which the loud pedal was always on, and the player in order to produce the greatest volume of sound struck all the notes at once. To the practiced ear the result would not be music. In the same way to the expert gunnery officer the idea of mounting as many guns as possible in a ship—it may be crowding them together so closely as to become a danger to the crew rather than the enemy—and firing them all at once is not effective gunnery. Naval shooting is no longer a matter of discharging a number of shells haphazard in the hope that a proportion of them will hit the enemy. It has become an exact science.

A battleship, or battleship-cruiser of the *Inflexible* type, is merely a floating gun platform. It is the child of the modern gun, and the modern gun is of a very different character from the weapon which was mounted in the navy even forty or fifty years ago. It is now a weapon of precision and of very high power. Some years ago Sir Andrew Noble gave some most interesting particulars of the guns which in 1850 formed the principal armament of British frigates or line-of-battleships, and we thus obtain material for comparison with the weapons carried by the newest ships being built and of the strides which the science of gunnery—of hitting an enemy first and hitting him hardest—has made. The progress of gunnery has been due to the marvelous series of triumphs achieved by the gun makers of the world, spurred on to further effort by a spirit of emulation, and by recurring improvements in armour manufacture. As a result strategy and tactics count for nothing if the ship's officers and men cannot use the guns so as to hit the enemy. The only object of a man-of-war and of all the laborious training of the crew is to hit first, to hit hard, and to keep on hitting.

Within a short period of 1850, the long peace which succeeded the Napoleonic wars was broken and at the time, within the vivid recollection of thousands of persons, the principal guns with which the ships were armed were old 32-pounders. They were, as Sir Andrew Noble recalled, weapons of rude construction, being mere blocks of cast iron, the sole machinery spent upon them being in the formation of the bore and the drilling of the vent. The carriage upon which

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THE VANGUARD, THE WORLD'S LARGEST DREADNOUGHT BATTLESHIP. BUILT BY VICKERS, SONS & MAXIM WITHIN TWO YEARS, A RECORD BUILDING PERFORMANCE

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THE BOW OF H. M. S. ST. VINCENT

this rude gun was mounted was even more rude. It was made entirely of wood. The recoil was controlled by the friction of abnormally large wooden axles and sometimes by wedges, the gun being finally brought to rest by the rope breeching which attached the piece to the vessel's side. The elevation was fixed by quoins resting on a quoin bed, and hand-spikes were used for training and elevating. In 1858 the committee on rifled cannon recommended the introduction of the rifled Armstrong gun, the advantage of this weapon in regard to range, accuracy and penetrative power being conspicuous. The increase in accuracy was, however, the point that attracted most attention. At a range of 1,000 yards half the shot from a rifled gun fell in a rectangle of about 23 yards long by one yard wide, while in the case of a smooth-bore gun the corresponding rectangle was about 145 yards long by 10 yards broad. After this period improvements made in powder enabled velocities of 1,200 and 1,300 foot-seconds to be raised to 1,600 foot-seconds, although the maximum pressure in the gun was considerably reduced. Certain experiments carried out at Elswick soon afterwards led to the velocities of rifled projectiles being at once raised from 1,600 foot-seconds to 2,100 foot-seconds, the maximum pressure remaining the same. The consequent increase of pressure by nearly 75 per cent. rendered necessary the reconstruction of guns and their mountings. In 1877 experiments destined to have important bearings on the progress of naval artillery were being made. For nearly seven centuries—since the days of Roger Bacon—gunpowder had had no serious competitor, but at last it was replaced by cordite, the advan-

tages of the newer explosive being the absence of smoke and an increase of energy of about 50 per cent. without a higher maximum chamber pressure.

Such was the early history of artillery as applied to men-of-war. It was a slow movement forward at first, but in the last decade or so it has advanced with extraordinary rapidity. The latest type of British naval gun of 50 calibres weighs 65.8 tons, will penetrate eight inches of armour at thirteen miles, and costs about £100 every time it is fired; its rate of fire may be as high as two rounds a minute, so quick is the method of loading and firing. This is the weapon mounted in the latest British battleships. Its length with the breech chamber added is 617.7 inches. The projectile, of 850 pounds in weight, has a muzzle velocity of 3,010 foot-seconds and a muzzle energy of 53,400 foot-tons. The fire delivery possibilities of this new gun are remarkable. During the proving tests two guns of the British battleship *Collingwood* mounted in one turret got off eight rounds in two minutes, and four guns in two turrets got off sixteen rounds in two minutes forty-five seconds, full service charges being used.

As an illustration of the progress of naval ordnance it may be added that in the former *Collingwood*—one of the old *Admiral* class—was mounted the first 12-inch breechloading gun and this weapon weighed forty tons, was 25.25 bores in length, and threw a projectile weighing 850 pounds, with a muzzle velocity of 1,914 foot-seconds and a muzzle energy of 18,130 foot-tons. It had a penetrative power equal to sixteen inches of wrought iron at 3,000 yards. The newest gun will penetrate 32.9 inches of wrought iron at the same range, the projectiles being identical in each case.

The Navy Department of the United States has recently perfected an even more remarkable weapon and experiments have been made in England with a new 13.5-inch gun. The American gun is of 14 inches and weighs 64 tons, or 10 tons more than the weapon which has just been placed in the battleships *North Dakota* and *Delaware*. Its extreme length is 53½ feet and it uses a projectile of 1,400 pounds. The shell will issue

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ST. VINCENT'S 12-INCH GUNS STARBOARD

from the muzzle—after traveling in the bore a distance of 542 inches—at the rate of 2,600 foot-seconds and its muzzle energy is 65,606 foot-tons, or 13,000 more than the *North Dakota* and *Delaware* guns. Its penetrative power is given as 22.7 inches of best Krupp armour at the muzzle and 13 inches at 9,000 yards.

This brief review indicates the strides which have been made in naval artillery since the old 32-pounder gun was regarded with something of wonder sixty years ago, but it conveys no adequate conception of the wonderful degree of accuracy in hitting which is now possible, and it is this which explains the attention which is now being paid to the training and practice of the gun's crews in all the navies of the world.

The whole theory of gunnery has been changed by the development of the gun. These new weapons must be used scientifically—range, direction, wind, light, the speed of the enemy and of the firing ship and many other points have to be considered. When it is remembered that an 850-projectile even from the latest gun takes 12 seconds to travel five miles, that during that time an enemy's ship will have traveled 120 yards if steaming at 20 knots, and that it is useless for another shot to be fired until the degree of accuracy of the first has been judged by the splash or the damage inflicted and connections have been made, it will be understood that mere rapidity of possible fire is a matter of less account than is sometimes imagined, since there is a limit beyond which it may prove merely waste of ammunition, of which the supply in a modern ship is restricted by reason of its heavy weight and the space which it occupies.

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VANGUARD'S AFT 12-INCH GUNS AND OBSERVATION PLATFORMS

These problems have led to the development of modern naval gunnery, of which Vice-Admiral Sir Percy Scott was the pioneer. In the British and American fleets the gunnery systems adopted are very similar. The reason is not far to seek. Commander W. Sims, of the United States Navy, was serving in the Far East at the time when Sir Percy Scott was developing his system of gunnery training. The result of this association of ideas may be seen in the designs of British and American battleships today, and the absence of this association of ideas accounts for the different mounting of guns adopted in other

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THE NORTH DAKOTA, THE LATEST AMERICAN DREADNOUGHT

Maximum trial speed, 22.25 knots at 35,150 horse-power over measured mile; 21.64 knots on four-hour trial, at 31,400 horse-power. Built by the Fore River Shipbuilding Company, and equipped with Curtis turbines

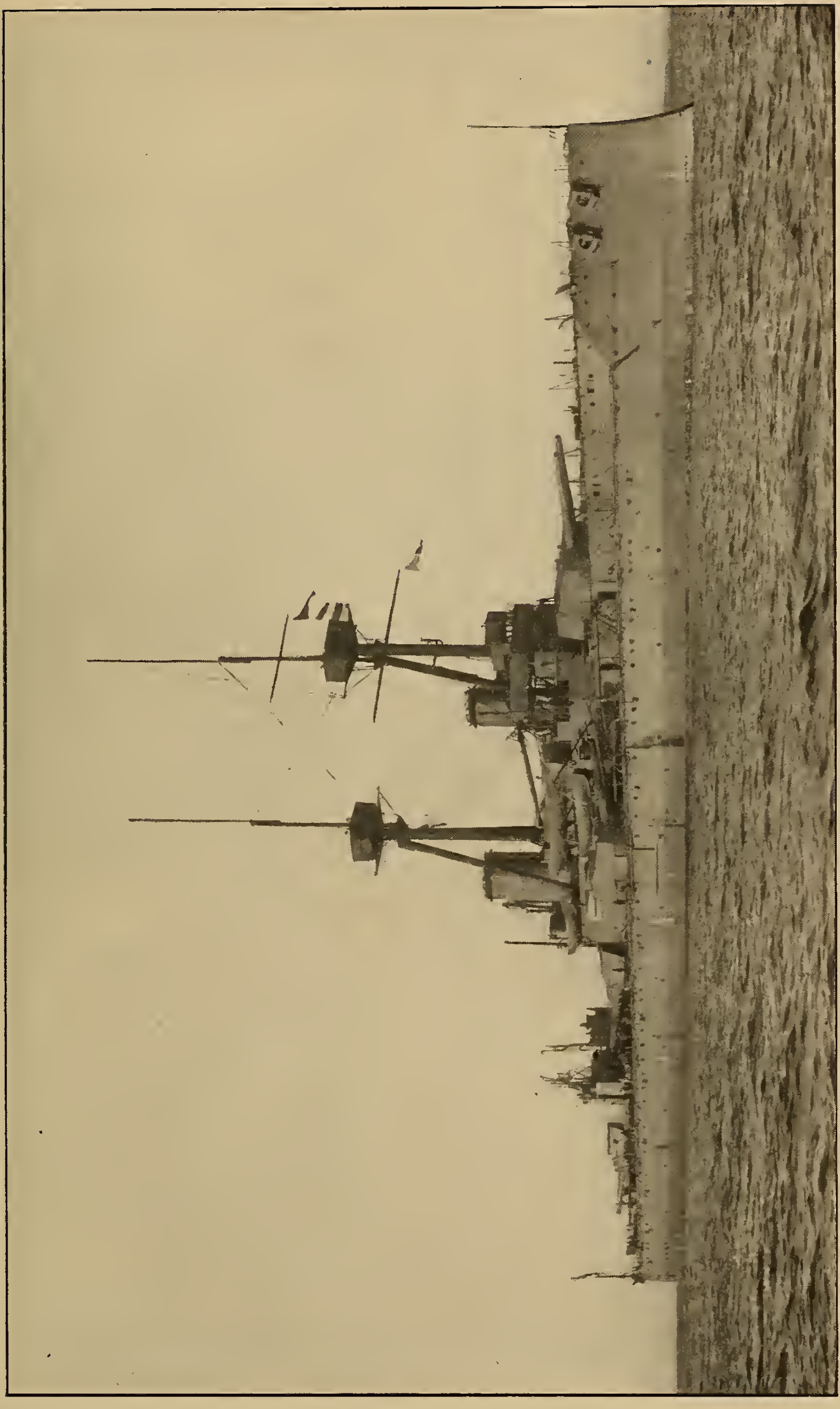
navies, of which the German may be regarded as a typical illustration. All the world is now bent on the construction of battleships of the all-big-gun type, but the principle first introduced in the British fleet is being carried out in various ways. The variations in design are revealed in the following very brief particulars of the battleships building for British, American, German, French, Brazilian, Italian, Russian and Japanese navies:

Navy	Name of Ship	Tons	Speed, Knots	Armament
British	Orion	22,500	21	X., 12 in., 50 cal.; XX., 4 in.
U. S. A.	Wyoming	26,000	20½	XII., 12 in., 50 cal.; XXII., 5 in.
German	Ostfriesland	22,000	20½	XII., 12 in., 50 cal.; XII., 5.9 in.; XVI., 3.4 in
France	Danton	18,300	22	IV., 12 in., 50 cal.; XII., 9.4 in., 50 cal.; 24 small quick-firers.
Brazil	Minas Geraes	19,250	21	XII., 12 in., 50 cal.; XXII., 4.7 in.
Italy	Dante Alighieri	18,300	23	XII., 12 in.; XVIII., 4.7 in.
Russia	Sevastopol	23,000	23	XII., 12 in.; XVI., 4.7 in.
Japan	Kawachi	20,800	20½	XII., 12 in.; X., 6 in.; XII., 4.7 in.

It will be seen that the designs adopted in the British and American fleets closely resemble each other, while in Germany and Japan some reduction in other fighting qualities is held to be compensated for by the mounting of 6-inch guns. It is a moot point, all things considered, which is the best anti-torpedo weapon, the 4-inch gun of the British service, the 4.7-inch gun of Italy and Russia, the 5-inch gun of the United States, or the 6-inch weapon adopted in Japanese and German battleships. In British and American designs only two types of gun are carried—the 12-inch, of which there are ten, and the 4 or 5-inch. In Germany, on the other hand, on a smaller displacement, which means a smaller deck space, they mount a large number of 12-inch guns in association with a secondary armament similar to that carried before the all-big-gun principle was introduced, as well as a number of quite small anti-torpedo weapons. The result of these variations in design is that the aggregate amount of metal which could be thrown by a German ship, for instance, is very much greater than the amount which could be discharged from a British or American if all the guns were fired simultaneously. The amateur critic is apt therefore to rush to the conclusion that the British and American vessels are of inferior fighting power.

It is impossible, however, to judge the relative merits of various ship designs by such an easy method of rule-of-thumb calculation. Many important factors must be taken into consideration before judgment is passed. Fighting efficiency, which is another word for ability to hit, does not depend on the multitude of guns mounted in a battleship, because the guns may be either of the wrong types or may be so crowded together as to interfere with one another. In judging the fighting efficiency of this battleship or that it is important to ascertain which has the highest facilities in hitting first, in hitting hard, and in keeping on hitting. The factors which enter into the consideration of this somewhat complicated subject were recently admirably summarized by an expert writing in the *Daily Telegraph* of London.

In the first place, there is the build of the vessel. She may be a lively ship which rolls, or she may be a fairly steady platform when at sea. The *Royal Sovereign* rolled over 30 degrees before she was fitted with bilge keels, and as a fighting unit of a fleet she and her seven sisters were consequently at a great disadvantage, as, indeed, are many foreign battleships to-day. It must be apparent that a steady ship is the desideratum of the gunnery officers; steadiness facilitates accuracy in laying the guns, and accuracy in laying the guns means more probability of hitting the enemy. The gun-layer is very much in the same position as a photographer. If the latter is mounted on an Irish jaunting-car with a fast-trotting cob he will find it difficult—indeed, impossible—to secure a picture. The steadier the camera the



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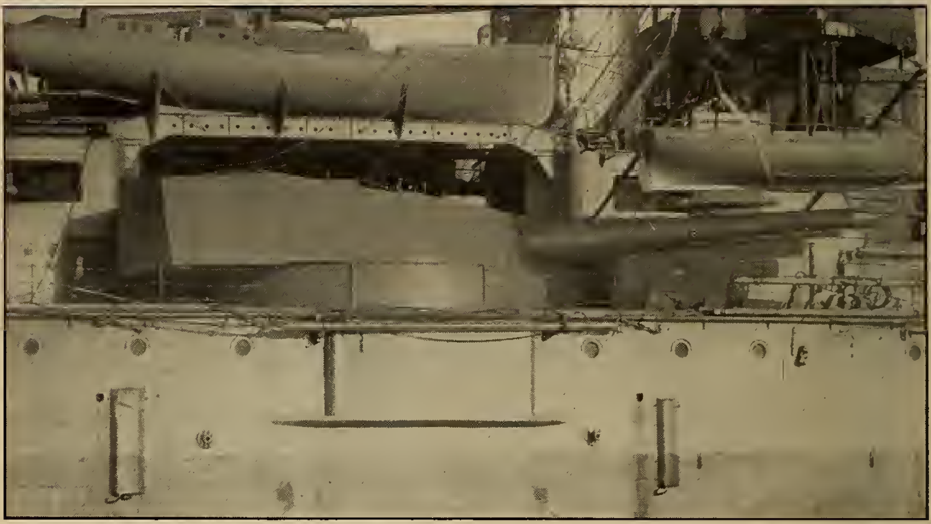
THE LATEST BRITISH DREADNOUGHT, H. M. S. ST. VINCENT

better defined the photograph, other things being equal.

Another consideration is the nature of the gun carried. With equal velocities, the heavier the gun the flatter is the trajectory, which again means more possibility of hitting. The aim of the gunnery officer is always to fight with a gun with a flat trajectory —that is, which fires the projectile so that it goes as straight as possible from the time it leaves the muzzle until it strikes an enemy's ship—it may be three, four or five miles away.

Then there is a third important point which cannot be ignored—the disposition of the armament. The guns may be badly placed in relation to one another or to the ship's structure. It follows as a matter of course that if one ship, owing to the wisdom with which the guns have been disposed, can bring more guns to bear on an enemy than another, she has more probability of hitting.

A further factor, comparatively new, but none the less of immense moment, is the method which is used for "controlling" the fire of the guns. This consists of some arrangement by which the officer or officers up above on a platform or platforms, with the advantage of a wider range of vision than can be obtained from the deck, "control" the actions of the gun's crews in the turrets by some system of mechanical signaling. There are various methods, some of which are radically unsound as a means of ensuring hits. In some cases the method is too complicated in its principles; in others the installation of the instruments may not be good.



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ST. VINCENT'S 12-INCH GUNS AMIDSHIPS

Much depends also upon the ability and experience of the officer controlling the fire, and upon the ability with which the gunlayers perform their duties. The marked superiority of some ships of the British navy over others of the same type at target practice illustrates this only too frequently; some fire many times as well as others.

Lastly, the nature of the armament will greatly affect the facility of control and the consequent hitting power.

None of these factors can be ignored in attempting to reach a solution of the relative merits of different battleships. By way of illustration we

may consider the development of British battleship design, and with slight variations the development has been similar in the United States navy. Ten years ago the typical ship was of 15,000 tons, mounting four 12-inch guns and twelve 6-inch weapons. Greater power was desired, so as to give to the British fleet ships of the line markedly superior to those being built in foreign navies. The Admiralty consequently laid down the *King Edward VIII.* class, carrying three descriptions of guns—four 12-inch, four 9.2-inch and ten 6-inch. Each description of gun required a separate officer aloft to control the group and a separate installation of instruments. Consequently in those days there were three distinct parties of officers and men in three distinct "stations" to control the three distinct descriptions of guns. In these circumstances it was soon discovered that confusion arose, and the hitting power of the ships was thereby reduced.

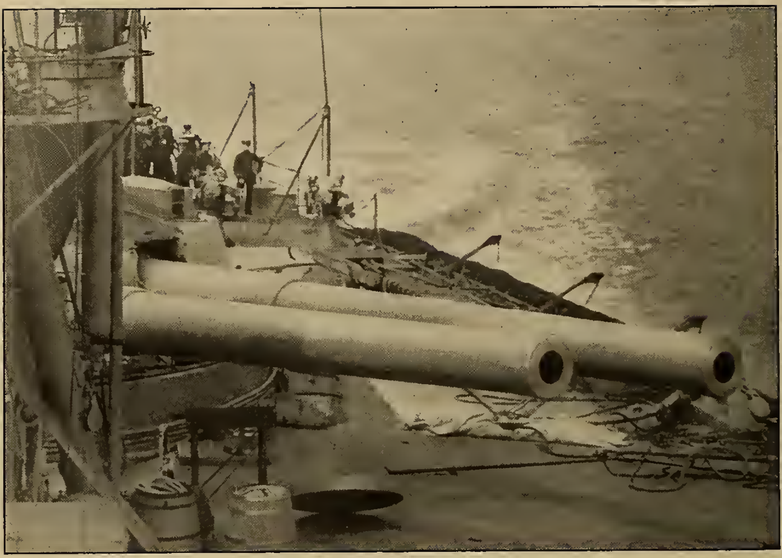
An improved design was forthwith prepared, and the British navy obtained the *Lord Nelson* and *Agamemnon,* in which the 6-inch guns were eliminated, leaving only two types of guns, and consequently only two "control" stations and two groups of control officers aloft. Thus we get this summary of naval development:

Formidable (15,000 tons)	King Edward VII. (16,350 tons)	Lord Nelson (16,500 tons)
4 12-in.	4 12-in.	4 12-in.
12 6-in.	4 9.2-in.	10 9.2-in.
	10 6-in.	

The *Lord Nelson* was hailed as the ship of a new epoch, and foreign navies almost immediately commenced to reconsider their designs — the French laying down six somewhat larger vessels embodying an armament of two types of guns.

Experience, however, showed that this dual control, though an improvement on that of the *King Edward VII.* class, was not satisfactory, particularly as in training the gun-layers—as would have been the case in battle—it was difficult to distinguish between the splashes made by the 850-pound shells of the 12-inch guns and the 380 shells of the 9.2-inch weapons, and therefore it was not easy to correct any error in the range. Thus it came about that leading gunnery experts, such as Vice-Admiral Sir Percy Scott in the British service and Commander William Sims in the United States fleet, decided that the only salvation was one type of big gun for battle and one fire control installation for the whole armament. Such a ship offered better facilities for obtaining a high standard of hitting power.

In this manner the British and American fleets came to adopt the all-big-gun principle as embodied in the latest types of men-of-war. In both navies an effort was made to secure the maximum hitting capacity on a limited displacement. This could be obtained only by the adoption of a new principle in association with the all-big-gun idea. Hitherto the big-gun battleship had carried two turrets each mounting two guns of the largest calibre able to fire on either broadside. Associated with this main armament there was a port and starboard battery of secondary guns. In these circumstances when such a vessel went into action, she could bring a broadside to bear of four big guns, but only half her secondary armament. Thus at a given moment in an action she carried a number of secondary guns, representing dead weight and unemployed guns' crews, which did not affect the momentary hitting power. The new principle which has been adopted in the latest English and American battleships is that with the elimination of the secondary armament the increased number of big guns shall be disposed as to enable all of them to be fired on either broadside. The result is that at a given moment of battle British and American ships will be able to concentrate on either broadside the whole of their main armament, and at the supreme moment there will be no weight carried or guns' crews of the main guns unemployed in the main business of war. In the German navy the designers have still clung to the old principle of multiplicity of



TWELVE-INCH GUNS OF THE DREADNOUGHT CLEARED FOR ACTION

guns, and consequently a proportion of the weight allotted to the main armament of the ships is ineffective at every moment during the period of action. For instance, whereas the British and American ships which are now being completed for sea can bring ten 12-inch guns to bear on either broadside, the German vessels, although they carry two more guns, can only bring the same number to bear on either broadside, and they suffer from the disadvantage that, owing to the introduction of the extra two guns, the weights assigned to armament are not only greatly increased, but, owing to the closer disposition of guns, there is liability to greater interference, and the strain upon the structure of the ship at the time of firing is also probably increased.

Now that a further increase in ship displacement is taking place, probably the battleship of the future will have sufficient deck space to enable twelve large guns to be mounted on the axial line so as to bear upon either broadside, but in any case it is certain that British and American constructors, in association with officers of the respective fleets, will evolve designs of their own—effective designs, which may not necessarily be in line with those of other constructors. In a technical matter of this kind, each navy must act up to its light and in accordance with its own predelictions and with the conditions obtaining at the time.

LONG-DISTANCE GAS TRANSMISSION

By Harrison Dexter Emerson

The possibilities of the transmission of fuel in the gaseous state by forcing it through pipe lines have been discussed at various times, and the question of cost, leakage, and general practicability examined. One phase of the subject involves the feasibility of generating fuel gas at the coal mines and the delivery of the gas to distant cities. So far as the operative problems connected with the actual pumping of gas are concerned, these have been taken out of the scope of conjecture and given practical demonstration in connection with the delivery of natural gas from the wells to the city of Pittsburg from points several hundred miles distant. Mr. Emerson gives some of the facts connected with the long-distance pumping of natural gas through pipe lines from the fields of Pennsylvania and West Virginia, and the data thus available will be welcomed as representing actual and efficient practice.—THE EDITOR.

POWER is transported in many ways. The principal method and the oldest is the shipment of coal or other fuel by rail or water lines from the point of production to the point of consumption. Electrical development has added another important method, in which the power is generated and carried or transported over transmission lines to the consumer. A third and very efficient method of handling power has been developed in the Pittsburg district, in Pennsylvania, by which natural gas is transported through pipe lines from the point of production to the consumer.

It is not the purpose of this paper to discuss the comparative efficiency of these three methods at the present time, but to outline the history of the development and the present state of the art of gas transmission, and point out possible future economical development.

It is of interest to note that these three methods of transporting power are radically different in one respect. The coal as it is shipped is energy stored, and the daily production and consumption have no direct relation to each other. In the transportation of gas the pipes act as a reservoir and the daily consumption and production must be equal, but the storage capacity of the pipes equalizes and reduces any temporary demands or temporary lull. With electricity consumption and production are equal and instantaneous, and the productive capacity must be equal to the temporary maximum demands of the consumers.

The natural gas industry in the Pittsburg district started first as the utilization of a waste or by-product from oil wells. Subsequently wells which were drilled for oil but failed therein and developed "gassers," were connected together to supply commercial and domestic fuel. Then longer pipe lines were built and there uprose the industry of supplying natural gas, competing with artificial gas and coal for light and fuel. In the early days the natural pressure from the wells was sufficient to force the gas through the pipes. But experience demonstrated that this natural pressure was unsatisfactory and unreliable, because it fluctuated widely under variations of consumption and under climatic conditions. When the demand became greatest—that is, in cold weather—the pressure decreased and the volume of gas flowing through the pipes diminished, and the supply was unsatisfactory.

The pressure on any particular well also diminishes as the well grows older. This decrease in pressure does not follow a regular rate, but is peculiar to each well.

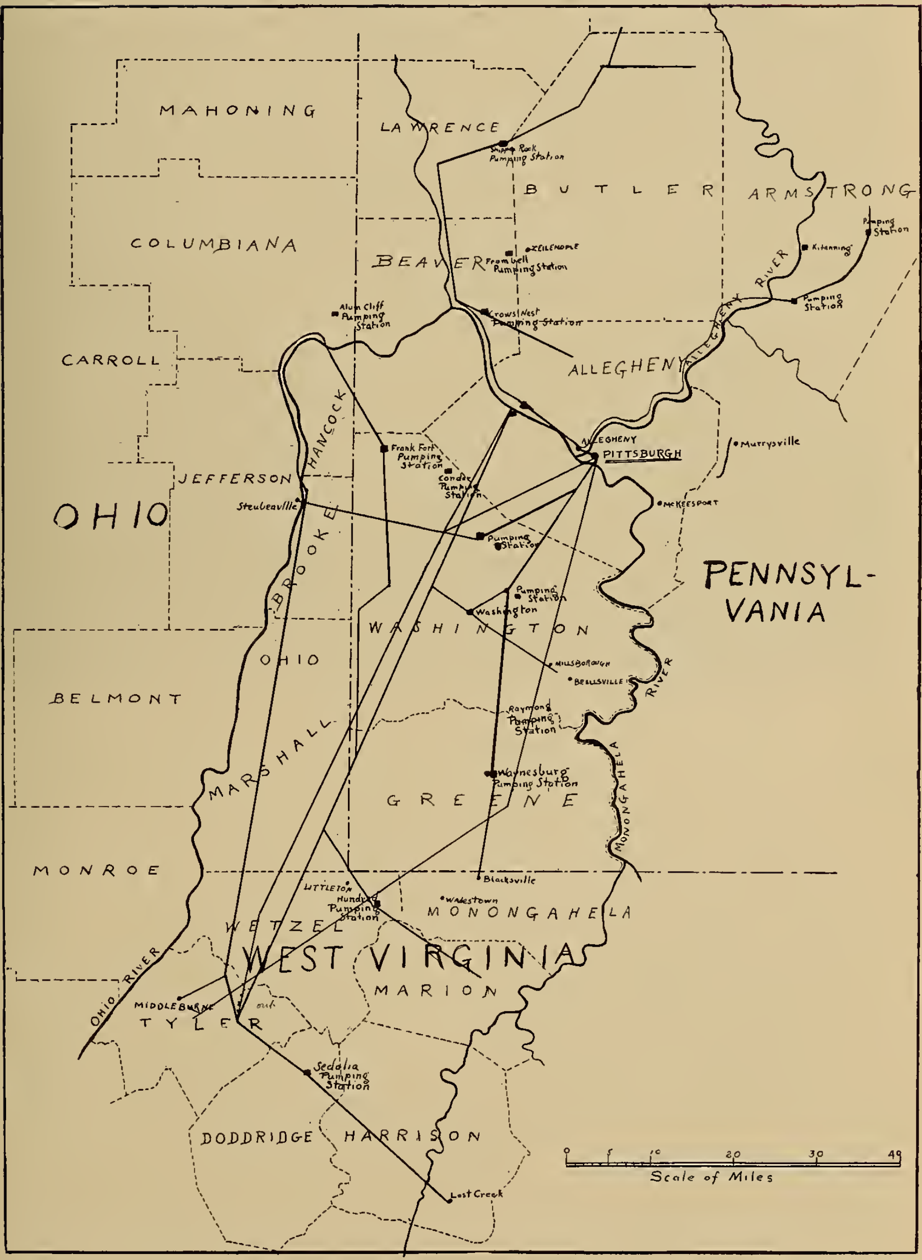
These conditions led to the building of pumping plants, taking the gas from the wells and putting it into the transporting or supplying mains at a different pressure. The first plants constructed were steam compression plants, the gas being burned

GAS PUMPING STATION AT WAYNESBORO, PENNSYLVANIA

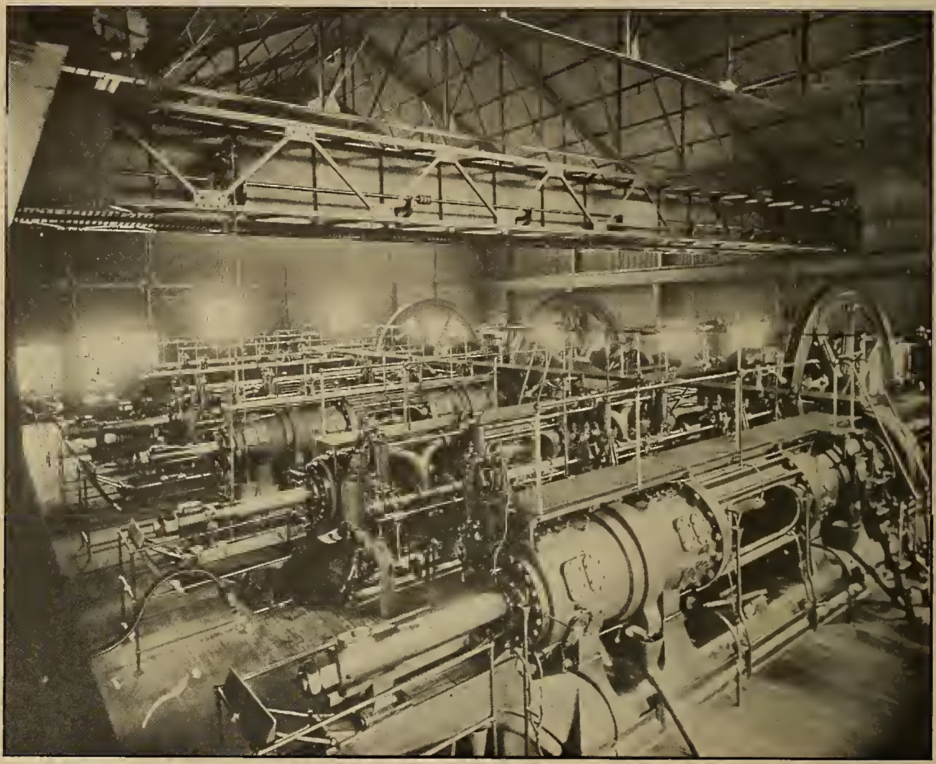
under boilers as a fuel and steam used to drive compressors very similar in design to those used for compressing air. Some of these plants, as installed near Pittsburg, were quite efficient. In one instance it is reported that it produced an indicated horse-power with 16 cubic feet of gas which was equivalent to about 8 per cent. of the gas compressed. This plant raised the pressure from atmosphere to 300 pounds.

Within the past few years, following the development of the gas or internal-combustion engine, large and very efficient plants have been constructed in which the natural gas is used directly to produce the motive power. Speaking of the results of the operation of one of these plants, the manager of one of the largest companies supplying Pittsburg with gas says: "Among modern gas-pumping machinery are some of the finest specimens of mechanic art. Probably nowhere has a greater amount of work been done with the same expenditure of fuel than has been accomplished in gas compressors; in fact, it is doubtful if the results have been equaled in any other power plants. An indicated horse-power has been maintained for one hour with less than the equivalent of two-thirds of a pound of coal. Thirty cubic feet of gas have been compressed with the expenditure of but 1 cubic foot of gas in producing the power."

Gas engines in units as large as 5,000 horse-power have been installed for this service, and an example of such a gas-power gas-pumping plant is shown in the accompanying illustrations, which represent the station at Waynesboro, Pa. These engines are provided with ingenious devices for starting and for regulation, in order to maintain a pre-determined uniform pressure in the delivery pipe



GENERAL LOCATION OF GAS-PUMPING PIPE LINES ENTERING PITTSBURG



INTERIOR OF GAS-PUMPING STATION AT WAYNESBORO, PENNSYLVANIA

Showing tandem gas-pumping engines in units of 5,000 horse-power, built by the Snow Steam Pump Company, Buffalo; also power traveling crane by the Whiting Foundry Equipment Company, Harvey, Illinois.

line, regardless of the volume passing through the pumps.

The labour employed by a plant such as that illustrated is ridiculously small when compared with the power generated, and is comparable only to the small amount of labour necessary to operate a hydro-electric plant, and it is questionable which form has the advantage over the other.

In pumping oil through pipes it is usual to pump it a certain distance and then use a relay pump for the next stage. In handling gas this is not as efficient a method as to compress the gas at the first station to a maximum density. The amount of gas that can be passed through a line between given points depends upon the difference between the squares of the initial and discharge pressures. It is much more economical to pump the gas with one high-stage compression at the initial end than to relay it with several low-stage compressions. The practical result of this experience is that the compressor plants are placed in convenient locations to the wells and the gas is forced through the transporting lines to the immediate vicinity of consumption, where the pressure in the city distributing lines is regulated by equalizing valves.

The principal cost of transporting gas—or, as it really is, power—through pipe lines is evidently the interest on the capital required, depreciation and maintenance. That there are many instances where this is much lower than rail or water haulage of an equal amount of power is unquestionable. Whether it is less than the electric methods is a mere guess, as

ANOTHER VIEW OF THE WAYNESBORO GAS PUMPING STATION

the companies which own the pipe lines have been very secretive about costs and maintenance charges. That it has been, and is, extremely profitable, is proved by the earnings of the companies which supply many cities in the territory served by the Pittsburg and West Virginia district.

Conservative investors have refrained from advocating the securities of these gas companies, not because the efficiency of the method of transporting was questioned, but because they were skeptical as to the continued supply of the natural fuel. As early as 1888 an English engineer, in a monograph on the then infant natural gas industry, called attention to the fact that, should the natural gas fail, the companies could erect coke ovens and send the artificial gas through their lines in place of the natural gas. It is immaterial whether the coke or the natural gas be considered the by-product of the modern improved oven, because either would pay all expenses and leave the other as a net clear profit.

Modern mechanical engineering is responsible for the fact that cities such as Cincinnati and Cleveland, located several hundred miles from the gas fields, are able to enjoy the advantages of a convenient low-priced and abundant gas fuel for commercial and domestic uses. The two principal elements which should be mentioned in this connection are the economical and efficient gas compressors as here illustrated, and riveted pipe lines which can be constructed at a reasonable rate, but which will stand high pressures without undue leakage.

It is reasonable to predict that plants will be constructed in the future to handle artificial gas alone, and when this is done a part of the now tremendous cost of handling and delivering coal in large cities will be eliminated, and a large economic saving will result.

THE ELECTRICAL DRIVING OF TEXTILE MACHINERY

By W. B. Woodhouse

MUCH of the discussion as to the relative merits of mechanical and electrical driving of textile machinery would have been avoided had it been possible to determine accurately the losses in mechanical transmission in a steam-driven mill, and it may be said that the practical difficulties in the way of doing this have largely tended to prevent a true appreciation of the efficiency of electrical driving.

Comparisons between different mills are of little value, and the electrical engineer is compelled to rest his claims for improvement on tests of individual machines and an inductive reasoning therefrom. That the claims of advantages are none the less true the following article is intended to show.

The principal claims made for electric driving are:

Lessened losses in transmission of power.

Increased steadiness of speed and output.

Improved financial results by the adoption of the electric drive.

MECHANICAL EFFICIENCY

The first point of importance is to decide the relative mechanical efficiency of the two methods.

On the electrical side it is a matter of extreme simplicity to determine not only the total friction and electrical losses, but to separate the losses in each department as tests may be made under actual operating conditions from day to day, and the effect of climatic conditions and wear observed with accuracy.

Unfortunately, with mechanical transmission it is impossible by practical methods to determine the losses to any degree of accuracy, and this inherent fault has had much to do with the comparatively slow adoption of electric driving.

The established method of estimating friction losses by indicator diagrams taken when the engine is driving only the shafting and belts is an inaccurate one for the following reasons:

All friction losses so recorded increase with load; the engine itself has smaller pressures in every part and less friction; the total pull in belts and ropes, due to their elasticity, and the loss of power increases with the load, and the pressure on shaft bearings increases also; gearing losses vary in the same way, and, except as a means of comparison from day to day, "friction" cards are valueless.

Mills vary so considerably in their equipment that it is difficult to state a figure of losses which is of general application; it may, however, be safely said that the electrical transmission from switchboard to machine is more efficient than the mechanical in practically every case.

The efficiency of a modern mill engine under load, after deducting the power required for pumps and auxiliaries, is of the order of 90 per cent. That is to say, the horse-power given out by the engine is 90 per cent. of the indicated horse-power.

The average efficiency of electric motors (of the sizes generally used) when running with from three-quarters to full load may be taken as the same, viz.: 90 per cent. That is to say, the useful horse-power given out by the engine is equal to the useful

FIG. 1A.—RECORD FROM FIRST MAIN SHAFT AT 80 R. P. M., DRIVING TOTAL MILL LOAD

horse-power given out by the motors; this being so, there are left to be considered the losses in belts, ropes, bearings and gearing in the mechanical drive as against the smaller amount of shafting losses in the electrical drive and the very small losses in wiring. If, therefore, the installation of motors reduces the amount of shafting and number of belts in a mill to any appreciable extent, the electric drive will be more efficient, and the amount of the gain will depend entirely on the reduction of shafting effected.

As an example of the amount of electrical losses, the following figures may be taken as representative for a 1,000 horse-power cotton spinning mill with group driving:

	Per Cent.
Losses in wiring	2.5
Losses in motors	9.0
Losses in shafting and belts	10.0
Total	21.5

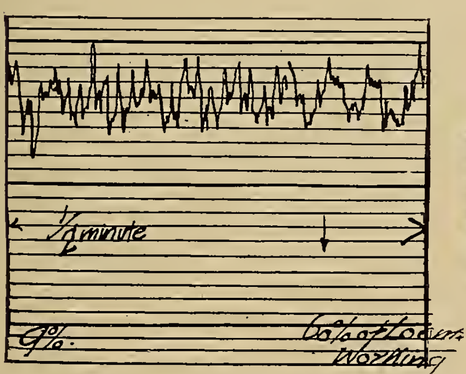


FIG. 1B.—RECORD TAKEN AT DRIVEN END OF SHAFT ON FOURTH FLOOR OF MILL, WEAVING DEPARTMENT

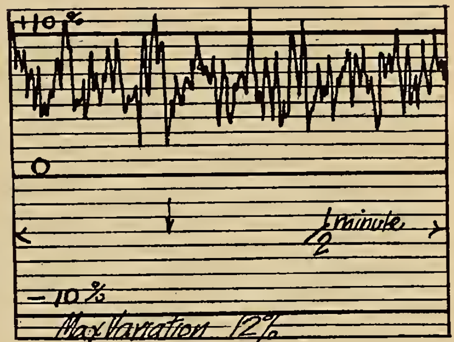


FIG. 1C.—RECORD TAKEN AT MIDDLE OF SHAFT

These results are not "paper" estimates, but are deduced from a number of exhaustive tests made by Mr. F. B. Perry and presented in a paper before the American Cotton Manufacturers' Association in 1906.

The no-load losses are, of course, much lighter in the case of electrical driving than mechanical; as an example, tests made by the writer in a woolen mill driven by motors of a total of 300 horse-power gave a no-load loss of 13 per cent.

The writer has tested a large number of mechanically-driven textile mills, and has rarely found the friction card to indicate less than 30 per cent. of the maximum power. In many cases it rises to 50 per cent. The conversion to electrical driving is accompanied by a very considerable reduction of the shafting and gearing and a corresponding reduction in the power used.

The electrical drive has one contingent advantage which may be mentioned here—the efficiency of that

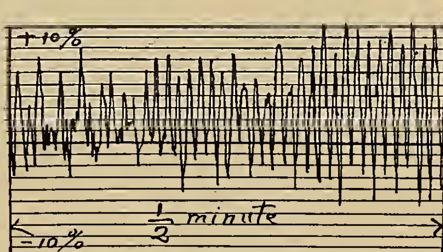


FIG. 1D.—RECORD TAKEN AT FAR END OF SHAFT, 120 FEET AWAY

shafting which is left may be maintained at its highest level by observing the power taken by each motor from day to day.

This is an advantage of no small value, as the adjustment of bearings, the working of lubricators, the tension of belts, and the wear of gearing may add considerably to the power required.

With mechanical transmission even the most careful supervision cannot keep the gearing up to its original efficiency.

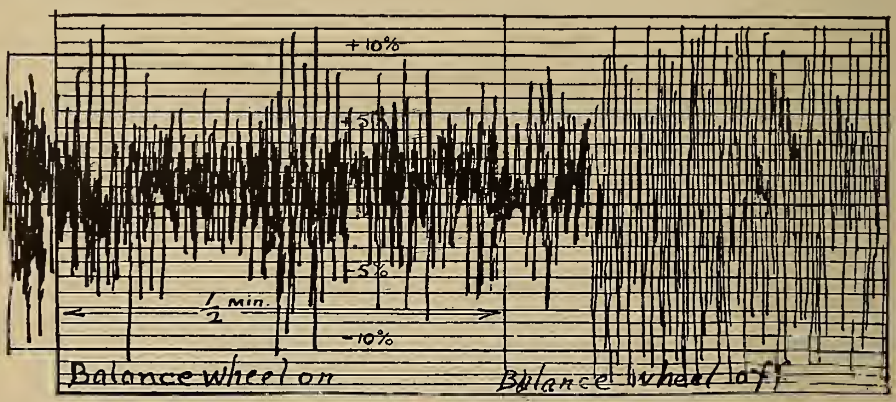


FIG. 2.—RECORD FROM WEAVING-SHED LINE SHAFT. EFFECT OF FLY-WHEEL ON OSCILLATIONS AT FAR END OF SHAFT

Electrical driving has enabled engineers to accurately measure transmission losses under practical conditions of use; it has shown, for example, the valuable reduction in starting friction, due to the use of ball-bearings; tests on spur-wheel gearing have shown the efficiency of a pair of wheels to drop from 96 per cent. when new to 78 per cent. when old; tests on belts have shown an average loss per belt of from 5 to 8 per cent. of the power transmitted; friction losses in bearings have also been estimated accurately, and the writer knows one case where, by changing the spindle oil, a manufacturer reduced the power taken by his frames by 10 per cent.

OUTPUT AND SPEED VARIATION

The second main issue is to determine the value of the claims put forward by electrical engineers for increased output and improved quality of material due to steady driving. The evidence of mill owners on this point is, of course, of the greatest value, but there is a natural disinclination on the part of most users of power to publish their results. That the claims are borne out the writer has ample evidence of a confidential nature; but, fortunately, in addition the claims can be readily corroborated by means of speed records taken from the textile machines when driven by the two methods.

The speed record of the engine is obviously of little value, as the shafts, belts and gearing transmitting the power to the machines are all capable of producing disturbances; records, to be of any value, must be taken from the machine whose output is under consideration.

The most convenient arrangement of textile machinery when mechanically driven is undoubtedly in long rooms, the line shaft being driven from the end. Apart from the extra cost of shafting, there is no serious disadvantage in driving spinning frames in this manner; but in the case of mule spinning or of weaving sheds the method is an unsatisfactory one, and there are few long weaving sheds so driven in which there is not a noticeable difference in the per-

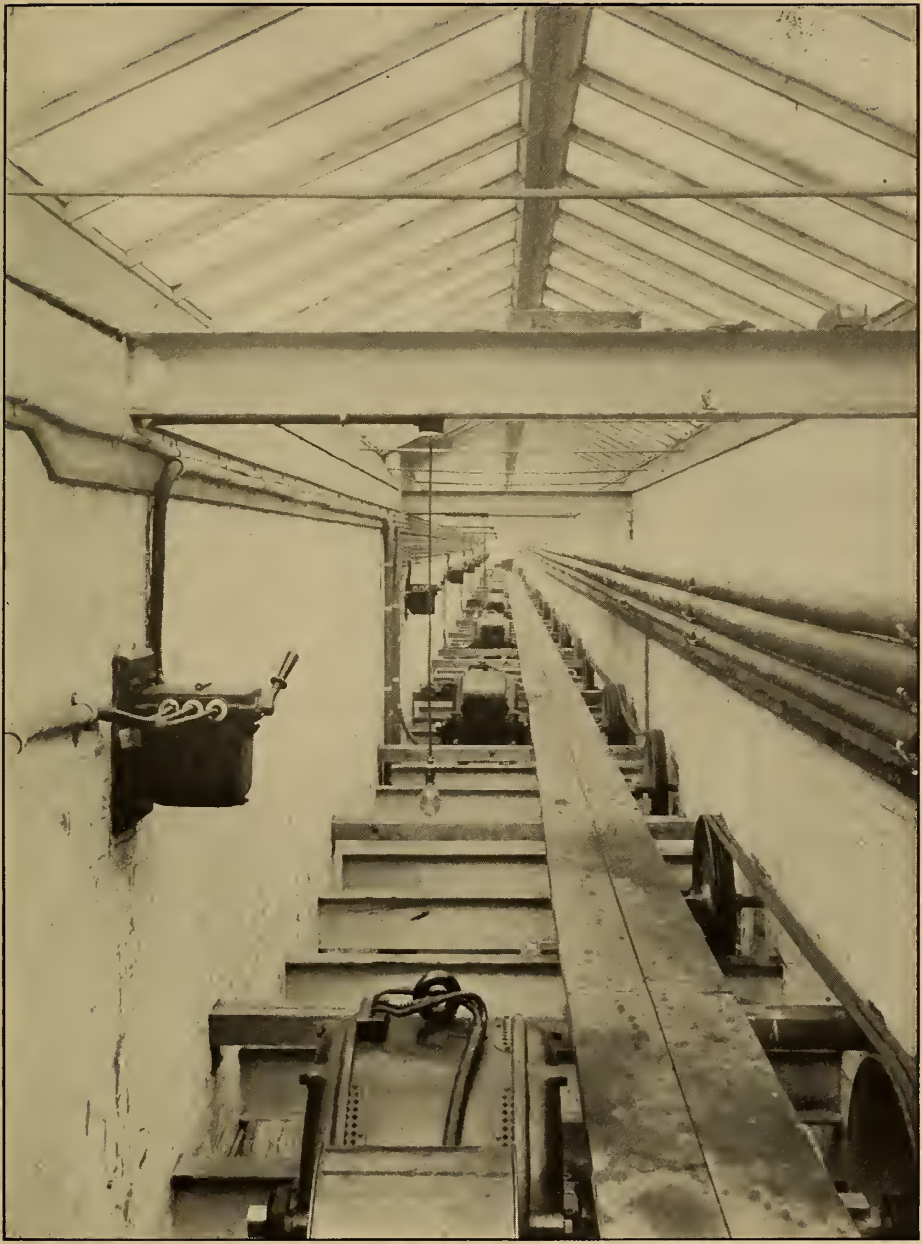


FIG. 3.—EIGHT 60-HORSE-POWER MOTORS, COMPLETE WITH STARTING GEAR, INSTALLED IN WEAVING-SHED ALLEY. BRITISH WESTINGHOUSE COMPANY, MANCHESTER.

Each motor drives three line shafts.

formance of the looms at the two ends. Those away from the driving end not only require more "tuning," but give more work to the weaver and produce a poorer quality of cloth.

The reason for this is that the line shaft, being subject all along its

FIG. 4.—VIEW ALONG WEAVING-SHED ALLEY

Taken underneath Fig. 3.

length to irregular resistances and being by its nature elastic, makes, as it rotates, torsional oscillations, which increase in magnitude as the distance from the driving end increases.

The results of speed tests in a large number of mills show this oscillation to exist in every case and to an amount rarely appreciated by the mill owner. The diagrams, Fig. 1,

FIG. 5.—VIEW OF WEAVING SHED IN A LANCASHIRE COTTON MILL. ELECTRIC GROUP DRIVING BY ALTERNATING-CURRENT MOTORS

show speed records of a typical woollen weaving shed in which thirty-four looms are driven from a line shaft 120 feet long, the line shaft being driven by an engine with a maximum speed variation of 5.5 per cent. It will be seen that the speed variation increases from 9 per cent. to 16.5 per cent., the latter a variation almost great enough to prevent the satisfactory operation of the end looms. Fig. 2 is a record from another mechanically-driven mill, the line shaft in this case driving the looms being 190 feet long and being itself, with other similar shafts, driven by bevel gearing from a cross shaft. The record is of interest as showing the result of a mechanical method of reducing the oscillations by belt driving a heavy fly-wheel from the far end of the shaft. The improvement made by this means can hardly be called a notable one.

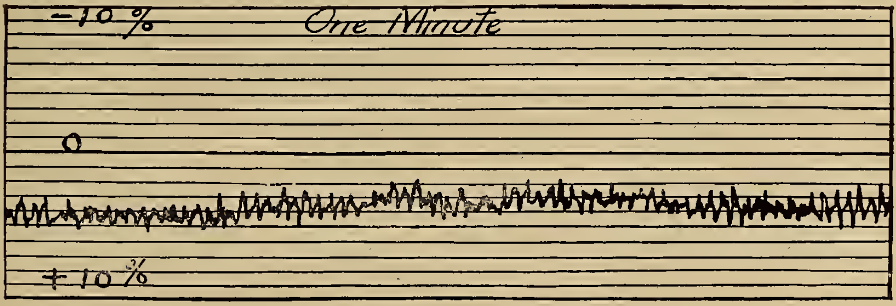


FIG. 6.—SPEED RECORD FROM ELECTRICALLY-DRIVEN WEAVING SHED LINE SHAFT

As a comparison, Fig. 6 is a record from the end of a motor-driven line shaft driving looms, the motor being fixed in the middle of the shaft.

When a machine is driven by successive belts and shafts from a main engine, an additional cause of speed variation is introduced—each shaft oscillates, each belt slips and creeps; moreover, the variation of speed caused by one class of machinery is reflected to the other machines all over the mill. There is also a variation from day to day which has effect in reducing output.

In considering such records as these there naturally arises the criticism that electrical driving of machinery in groups does not altogether do away with belts, and slipping will not be altogether obviated. This is, of course, the case, and the relative merits of group and individual driving for each class of machinery require careful consideration.

GROUP VERSUS INDIVIDUAL DRIVING

From a consideration of the power used to motor-drive textile machinery in groups or individually by a motor to each machine, and from speed records taken in the two cases, the results are, in practically every case, favourable to the latter method; but the problem must, of course, be settled by financial considerations. The saving in power and the steadier speed of the individual drive are offset to a greater or less extent by the extra cost of the smaller motors per horse-power and by the necessity for a margin of power on each motor greater in total than that required in a group drive.

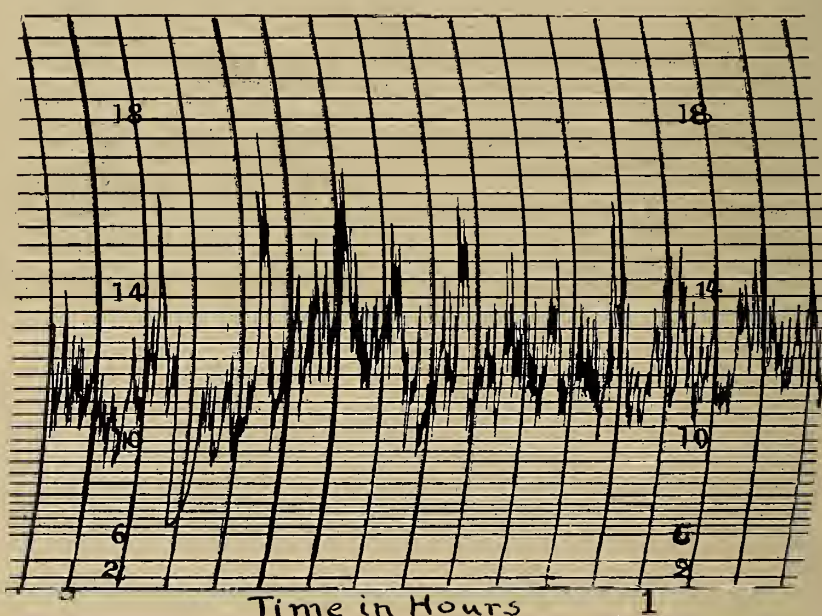


FIG. 7.—REPRESENTATIVE CHART OF POWER TAKEN BY LOOMS

Fig. 7 is a power chart taken from a motor driving twenty-eight looms, of which an average of twenty-four were in use at any one time. The fluctuations are such that the individual drive would require motors of a total capacity 15 per cent. in excess of that of the single large motor and costing more than twice as much. The decision must, however, be made by a consideration of the total costs and the value of the product in each case. The use of the

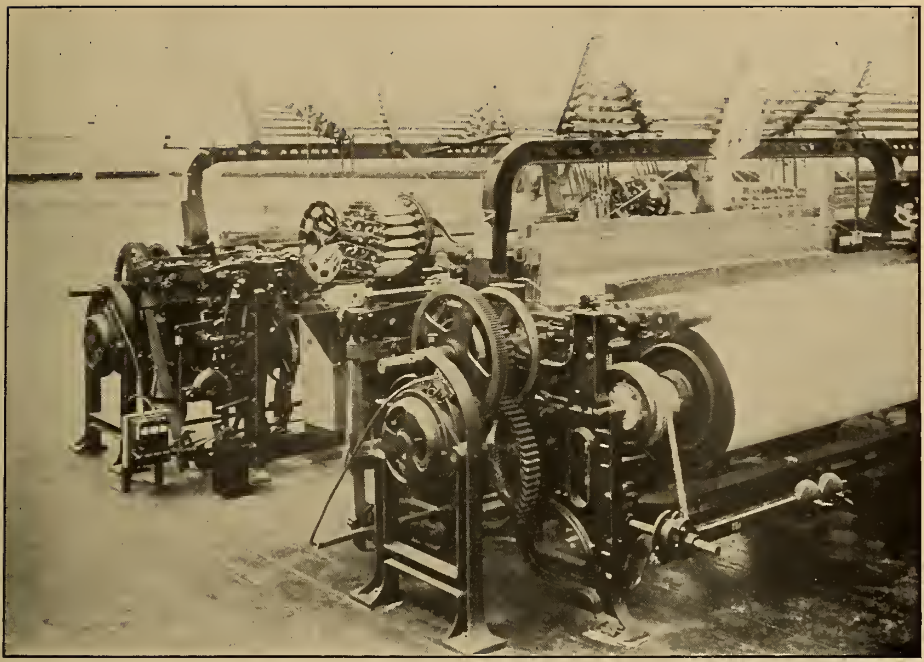


FIG. 8.—THE INDIVIDUAL DRIVE OF LOOMS BY MOTORS WITH FRICTION COUPLING. SIEMENS BROTHERS, LONDON

individual drive will increase the output and the capital expenditure on motors. It will decrease the cost of power and the proportion of establishment charges; if the value of the first two items exceeds the latter, then it will be advantageous to adopt the individual drive.

CONTINUOUS CURRENT VERSUS ALTERNATING

The conditions under which a motor has to work in a textile mill are not favourable to the use of commutating machines unless they are completely enclosed and separately ventilated. The temperature in certain departments frequently rises to 80 or 90 degrees Fahr., the air is humid, and a quantity of dust and lint is deposited from it, both conditions tending to cause sparking of the brushes.

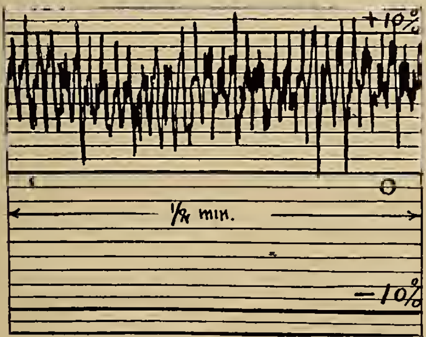


FIG. 9A.—NO LOAD VARIATION ON COUNTERSHAFT, MULE STANDING. STEAM ENGINE DRIVING

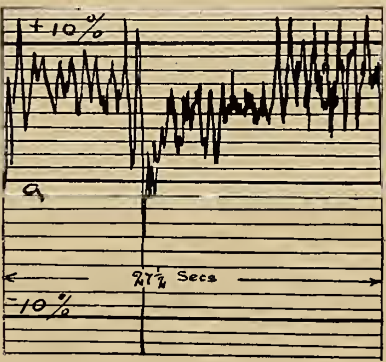


FIG. 9B.—VARIATION OF COUNTERSHAFT SPEED, MULE RUNNING, NORMAL WORKING CONDITION; STEAM ENGINE DRIVING

Usually every available foot of floor surface is occupied by the machinery, and it is necessary to fix the motors to the walls or ceilings; this being so, the motors are somewhat difficult of access and cannot receive the regular and frequent attention required by a direct-current machine.

The induction motor only requires attention at long intervals for the purpose of inspecting bearings and cleaning, and may quite properly be fixed in such places. For the majority of textile machines constant and uniform speed is a matter of the first importance. On this vital point the direct-current motor has inherent defects.

A synchronous alternating-current motor will run at absolutely constant speed; an induction motor will vary in speed from no load to full load by 2½ to 3 per cent; but this variation is independent of voltage variation and temperature. When driving a steady load the motor is practically a constant-speed machine.

The direct-current motor, even on an absolutely uniform load, will vary in speed, due to these causes; the writer has known cases where the speed in the afternoon, by which time the field coils had heated up, exceeded the morning speed by 8 per cent. Regulation can, of course, be effected by a rheostat; but carelessness in the use of this might cause serious trouble, and, at best, its use can only be regarded as a makeshift.

Where the direct-current motor is driving a load of a rapidly varying nature a more serious disadvantage appears in its inability to respond instantaneously to a change of load. This may be illustrated by reference to Figs. 9, 11 and 12, which are typical speed records taken from mules; first, driven mechanically by belts from a main engine; second, driven by a direct-current motor supplied from a compound-wound, engine-driven, direct-current generator; third, driven by an induction motor supplied with alternating current from the public mains.

FIG. 10.—CURVE SHOWING VARIATION IN POWER REQUIRED DURING ONE COMPLETE CYCLE BY SELF-ACTING MULE

The load curve corresponding is shown in Fig. 10, and it will be seen that the direct-current motor gives a speed curve which is a reflection of the changes of load. The explanation is a simple one, but this peculiarity makes such a motor en-

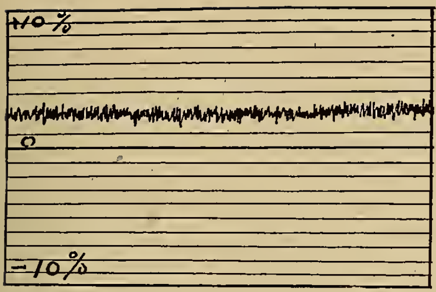


FIG. 11.—RECORD FROM MAIN SHAFT, NO LOAD, ALL MULES STANDING. DIRECT-CURRENT DRIVING

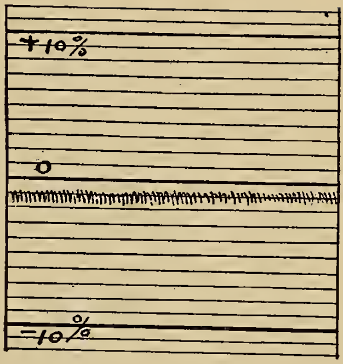


FIG. 12.—RECORD FROM MAIN SHAFT, NO LOAD, ALL MULES STANDING, ALTERNATING-CURRENT DRIVING

FIG. 11A.—RECORD FROM MAIN SHAFT, ALL FOUR MULES RUNNING, NORMAL WORKING CONDITION, DIRECT-CURRENT DRIVING

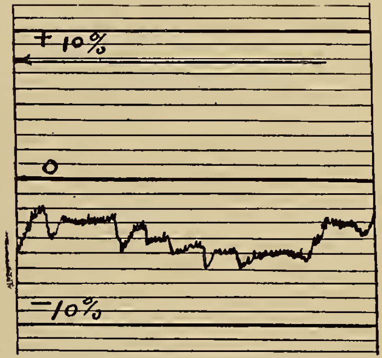


FIG. 12A.—RECORD FROM MAIN SHAFT, ALL FOUR MULES RUNNING, NORMAL WORKING CONDITION

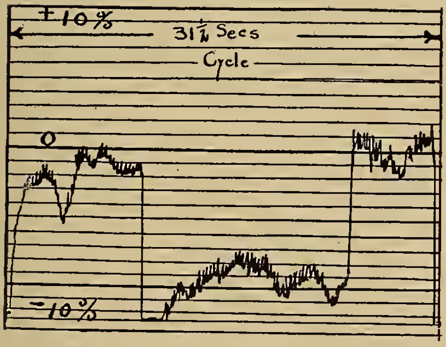


FIG. 11B.—RECORD FROM COUNTERSHAFT OF ONE MULE. ALL MULES RUNNING. DIRECT-CURRENT DRIVING

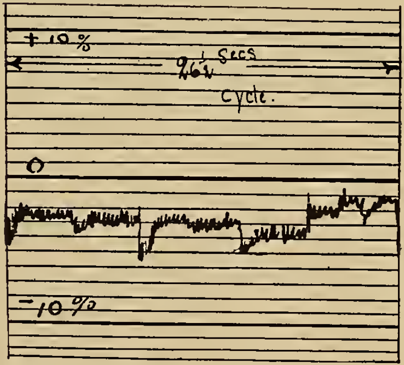


FIG. 12B.—RECORD FROM MULE COUNTERSHAFT, ALL FOUR MULES RUNNING, ALTERNATING-CURRENT DRIVING

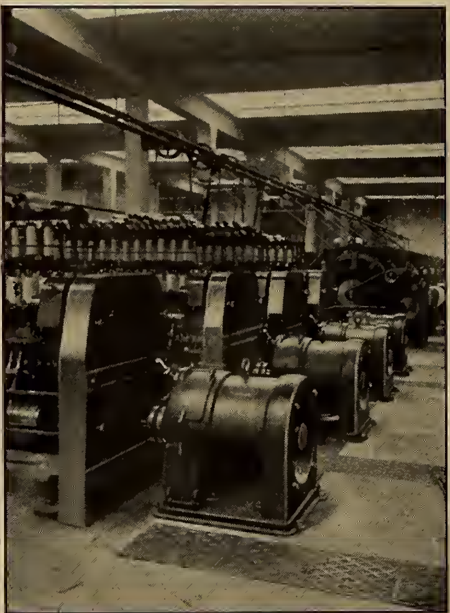


FIG. 13.—RING SPINNING FRAMES DRIVEN INDIVIDUALLY BY VARIABLE-SPEED A.-C. MOTORS DIRECT COUPLED TO TIN ROLLER SHAFTS. SIEMENS BROTHERS, LONDON

tirely unsuitable for driving such machinery.

The speed curves referred to were taken from the same mules in all cases, and it is interesting to note the marked superiority of the induction motor over both the mechanical and direct-current methods.

THE FINANCIAL ASPECT

Many wild statements have been made on the subject of power costs in textile mills, and they have, for many reasons, been difficult to check. The enthusiast who, from a test of a new engine lasting but a few hours and carried out under the most favourable conditions, calculates the annual cost of running by mere multiplication of the coal account, takes no notice of the deterioration that every machine must suffer, and makes no allowance for the numerous trifling losses which, over a period of time, amount in practice to a considerable figure. The careful analysis of costs kept and published by the public electrical generating stations in England are, perhaps, the most instructive comment on this sort of estimating. These results have shown that the difference between test figures and actual results accounts for increases of coal consumption of from 20 to 50 per cent. But perhaps the greatest difficulty the electrical engineer has had to meet has been due to imperfect and incomplete accounts kept of the power bill. There are still manufacturers who are content to regard the coal bill as representing their total power costs.

An analysis of a power account should include the following items:

Interest on capital expended on power plant, dam, chimney, buildings, engines, boilers, piping, main shafts, belts and ropes, and all auxiliaries.

Depreciation on the same.

Coal costs, including cartage and disposal of ashes.

Wages of enginemen and stokers.

Stores and sundries, oil packing, etc.

Water, or cost of pumping.

Repairs on engines, boilers, etc., boiler cleaning, maintenance of belts, ropes and shafting.

Rent, rates and taxes chargeable to the power plant and insurance.

These items will vary according to the local conditions in each case; but, generally speaking, the proportion remains fairlv constant. Capital charges are about one-half and coal from 25 to 35 per cent. of the total.

The proportion depends upon the running hours and the variations of load during these hours; for textile mills have not, as is sometimes assumed, a constant load throughout the day, and the load varies day by day, due to conditions of trade and climate.

The load factor, to use an electrical phrase, is rarely greater than 80 per cent. during running hours, and over the year the load factor of most mills lies between 18 and 25 per cent. That is to say, though

FIG. 14.—RING-DOUBLING FRAMES INDIVIDUALLY DRIVEN BY CONSTANT SPEED A.-C. MOTORS DIRECT COUPLED TO THE TIN ROLLER SHAFT. (BRITISH THOMSON-HOUSTON COMPANY)

the working hours may be one-third of the year, the current used in that time is less than that due to a perfectly steady load. A neglect of this important fact has accounted for many unfair estimates of the cost of electrical driving.

The annual cost of steam driving per I. H. P. varies from £3 to £5, depending on the size of the mill and the hours of working.

The equivalent electrical cost per unit can only be stated when the nature of the load is known; but, as an example, the costs of a 700 I. H. P. steam plant are given and the equivalent cost per unit of electricity calculated.

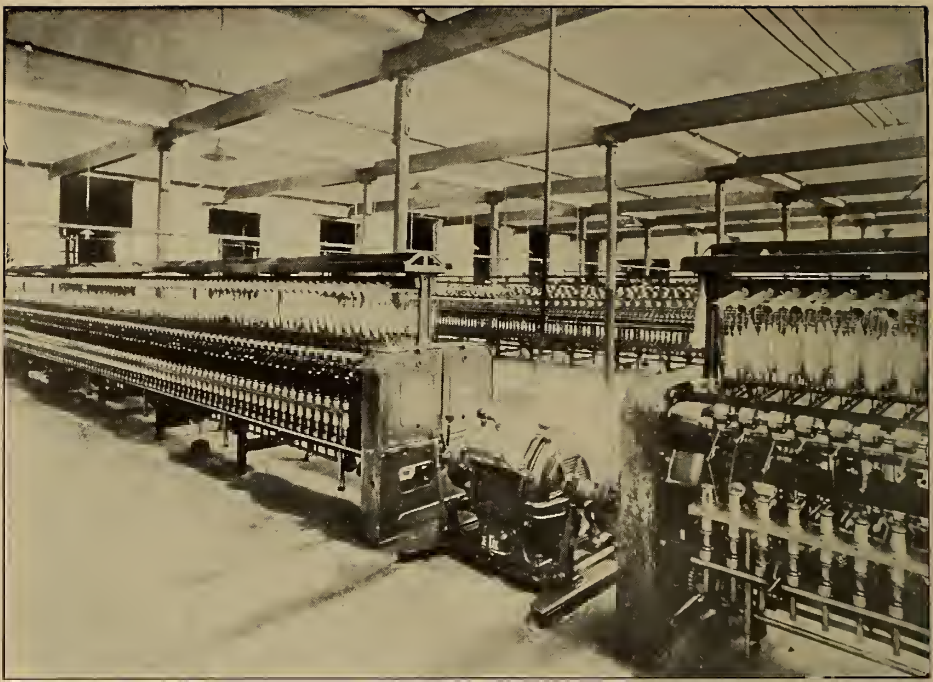


FIG. 15.—ALTERNATING-CURRENT MOTOR DIRECT COUPLED TO THE TIN ROLLER SHAFTS OF TWO RING-TWISTING FRAMES. (BRITISH THOMSON-HOUSTON COMPANY)

Note the friction clutch for each frame

Capital cost of plant, £7,500.

	Annual Cost	Equivalent Pence Per Unit
Interest and depreciation at 12½ per cent...........	£937	0.224
Coal at 10 shillings per ton.	700	0.168
Wages	250	0.060
Repairs	150	0.036
Stores	50	0.012
Rates, insurance, etc......	150	0.036
	£2,237	0.536

The final test of the value of electric driving is its effect on the balance sheet, and it is here that the value of increased output becomes most apparent.

The cost of equipping a mill with motors, assuming a public supply of power be taken, is less than the cost of boilers, engine and main drives by usually one-half. If this saving be invested in productive machinery, the earning capacity of the mill and of the capital invested in it is increased.

An extra output, due to steady speed, will be obtained in addition to this, and without any addition to the standing charges.

The balance sheet will, therefore, show a two-fold improvement.

The proportions of the items considered above will vary for each particular trade, but the general principles stand, that money expended on productive machinery is earning the profit, all other expenditure is a dead weight on the business, and that extra output, due to improved driving, will enable a greater profit to be earned without any increase of capital or standing charges; "dumping," of which so much has been heard recently, is only possible on account of this principle.

Electric driving can justify the claims made for it, and, this being so, the problem for the mill owner is no longer an engineering but a financial one. It has come to stay, and no mill owner can afford to neglect the lesson of the figures given above.

In conclusion, a few notes on the methods of electrical driving may be of interest.

The low working costs obtained in modern mechanically-driven textile mills are very largely due to the excellent millwrighting put into them, embodying, as it does, the results of many years of experience.

Electrical driving may give unsatisfactory results if the importance of the millwright's work is not realized, and although the results of any particular method of driving may be readily measured, foresight in the first case will save disappointment.

Mechanically, the best method of driving spinning frames is by direct coupling the motor to the tin roller, as illustrated in Figs. 13, 14 and 15. The fear that such an arrangement would cause too severe a stress on the yarn and bands when starting has been found in practice to be unjustified, and for a frame spinning one particular count of yarn at all times the method of driving is unequaled.

In converting existing frames designed for mechanical driving, it is an advantage to increase the speed of the tin roller in relation to that of the spindles; the ratio of the speeds is usually of the order of 10 to 1, and a reduction of this will give a more satisfactory drive and enable a high-speed motor to be used.

Where, as in the woolen trade, spinning frames are regularly working on different counts of yarn, direct coupling can only be applied if a change speed gear is part of the frame, otherwise the most satisfactory arrangement is to fix the motor to the ceiling in the place usually occupied by the gallows pulleys and

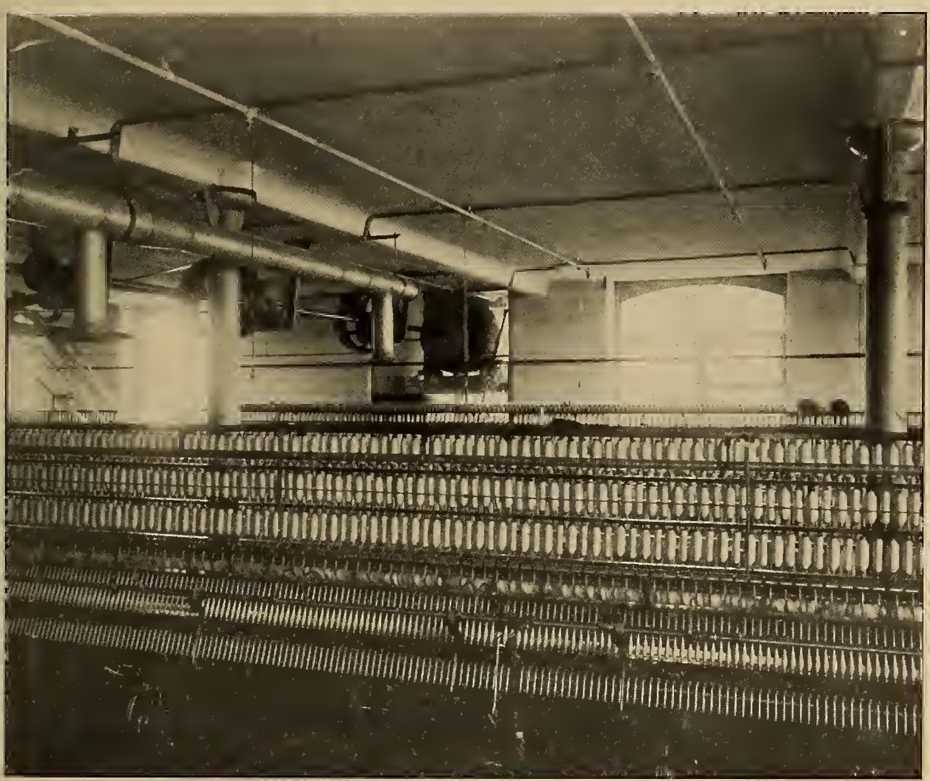


FIG. 16.—GROUP DRIVE OF MULE SPINNING ROOM IN A LANCASHIRE MILL. ALTERNATING-CURRENT MOTOR OF 90 HORSE-POWER DIRECT COUPLED TO MAIN SHAFT

to drive by a belt. An excellent arrangement, which allows of larger and proportionately cheaper motors being used, is to drive two or four frames from one motor; in the latter case the motor is provided with a double-width pulley at each end and the belts work side by side.

Mules are usually driven in groups of two or four by one motor, this being found to pay better than applying a motor to each mule. A group drive is illustrated by Fig. 16. The load on each mule is, of course, extremely variable; the grouping tends to equalize it. The load factor of a single mule is less than 50 per cent. during working hours; that is to say, the current consumption per horse-power is one-half of that due to a steady load. In addition to the cyclical variation of a mule load, there is a notable increase in the power required for the first hour after starting in the morning.

The individual driving of looms has proved successful in many cases, particularly in silk weaving, where extra cleanness, due to the absence of belts, is a great advantage. Mechanically, the method is most satisfactory; commercially, the advantages are, in most cases, not sufficient to justify the extra expenditure. The output from a loom varies so much with the skill of the weaver that mill owners can hardly be blamed for neglecting an increased output of 2 to 3 per cent. when the output due to the human element may vary by as much as 30 per cent.

The usual method of driving is in groups of ten to sixteen from a motor-driven line shaft, the motor being fixed at the middle of the shaft to reduce torsional oscillations, and the results obtained are highly satisfactory.

Preparing machinery, such as cotton openers and woolen willeys and shakers, is somewhat variable in its load. Carding and scribbling machines are very steady, and for this reason are usually group-driven; electrical driving shows an interesting increase in the power required by such machines after "fettling."

In woolen mills the milling department requires a large and variable amount of power, and group driving usually presents advantages over individual. This department is frequently worked overtime, and the advantages of a public supply of electric power in such case are considerable.

Many figures have been published of the power required by textile machinery, but unless very full details are given of the machines, a statement of horse-power is not of great value; the importance of knowing the average consumption of energy as well as the maximum power is to be borne in mind. The steady accumulation of data by electrical engineers is daily making the task of estimating the current consumption easier, and it is now possible to do this very closely, and to predict accurately the lessened consumption due to variations of load.

THE BRATTLEBORO HYDRO-ELECTRIC PLANT

By Lauriston Fredericks

In the issue of this magazine for September last, the possibilities of hydraulic-power development from streams of moderate fall and large volume of flow were discussed, and it was shown that there was no necessity to search for great waterfalls to secure abundant power for industrial operations. In the present article there is given a concrete example of the extent to which hydraulic power is being developed upon the Connecticut River, at Brattleboro, so that 20,000 horse-power is taken from the river, utilizing a head of about 15 feet.—The Editor.

WITH the completion of the great hydraulic power plant upon the Connecticut River, at a point just below Brattleboro, and not far from the boundary line of Massachusetts, it will become possible to deliver power by electric transmission to two-score cities within a radius of 60 miles.

The power plant has involved the construction of a dam 650 feet long and 34 feet high above low-water mark, requiring the labour of 700 men, in alternate gangs, twenty hours a day for two years, and costing about three million dollars.

In view of the advantages offered by hydraulic power and by electric transmission, together with the opportunities for utilization of power within reasonable distances of the site, the greatest hydro-electric plant in the United States east of Niagara has been constructed at Brattleboro.

The dam is built upon a rock formation which reaches clear across the river at a point about opposite the Vernon station of the Central Vermont Railroad. This ledge is jointed by Nature right into the outcropping rock upon either shore, while the high land beyond afforded the necessary protection from the stream at all times.

Between Bellow's Falls, in Vermont, and Turner's Falls, in Massachusetts, there is a reach of something like 50 miles, in which the river has a fall of 55 feet. There were no dams in this stretch; indeed, the big watershed of the Connecticut had never been used for commercial purposes at all except for direct water-power at Holyoke, Windsor Locks and Turner's Falls.

It was in July, 1907, that the first section of the coffer-dam cribbing was sunk at Cooper's Point. Long before that time a suspension bridge had been swung across the river, offices, storehouses, shanties and a hospital had been built, a spur track from the railroad put down, a saw-mill erected, and a power plant for furnishing electric light and moving cranes and hoists had been completed. In September, 1907, the full current of the river was deflected to the west of the rocks that were in the middle of the channel. The bluff was washed away at the rate of 1,000 cubic yards a day by a 4-inch stream of water driven by a 50 horse-power engine. The rock for the concrete for the bed of the permanent dam behind the coffer-dam was taken from the New Hampshire end of the ledge, where a luckily-located quarry was found; it was crushed on the spot and mixed and delivered with a very small amount of labour. In each yard of concrete there were mixed 24 cubic feet of loose broken rock, 4 cubic feet of cement and 12 cubic feet of sand. The width of the concrete bed in the deepest parts of the river was 65 feet at the base and on shore it was 20 feet. First the eastern half of the dam was built up from the river's bottom and then the western, stretching, from foundation to crest, 70 feet.

The power house is on the western

WASHING AWAY THE BLUFF ON THE NEW HAMPSHIRE SHORE BY A 4-INCH WATER JET

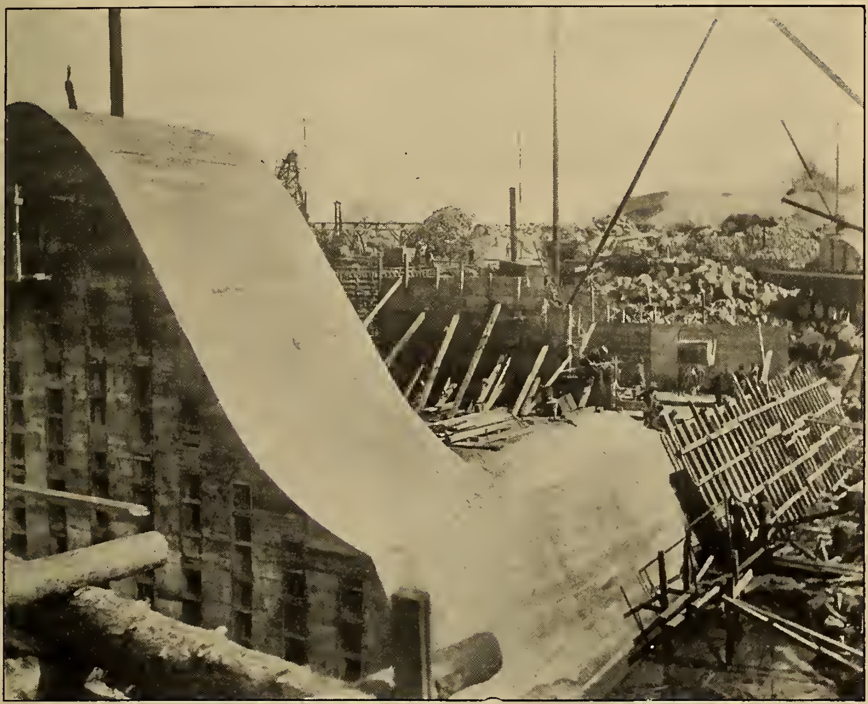
side. It stands on the dam itself, and is 50 feet in height and 250 feet in length. The logway for the yearly log crop is next to it, and beyond is the water spillway, wider than was the width of the river when the building of the dam was begun.

There are ten large flood gates.

DISASTROUS EFFECT OF A FLOOD OCCURRING DURING THE EARLY CONSTRUCTION PERIOD OF THE DAM

each measuring 7 feet by 10 feet, and capable, together, of carrying off 25,000 cubic feet of water piercing the dam. They will be used in times of ordinary flood to prevent excessive damage to land upstream and to regulate the level of the pond which is created by the dam. They move in a steel framework embedded in concrete. Through the solid masonry of the dam there has been made a tunnel or foot passage, through which a man can pass with 6 feet of concrete between him and the river above his head. Thus he will have access to the hoists which operate these gates.

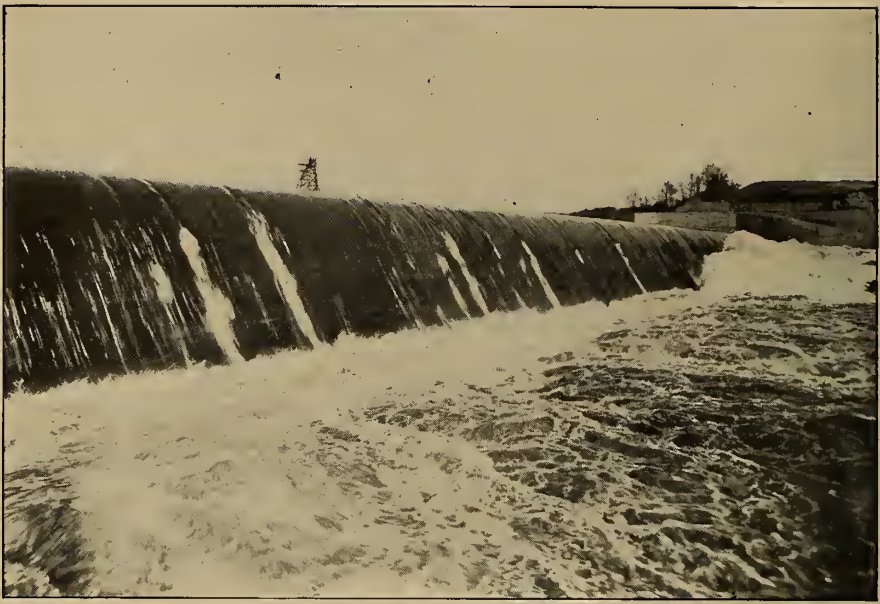
The dam creates a 22-mile reservoir, on the upper 4 feet of which the storage capacity has been computed to be 250,000,000 cubic feet of water. Thus the level of the stream is raised about 15 feet at Brattleboro, and where once there were rapids two miles above the city there is now still water.



VIEW DURING CONSTRUCTION, SHOWING SECTION OF THE DAM

In the power house there are eight vertical water-wheel units which develop 20,000 horse-power. Each of these units is connected directly with an alternating-current generator which has a capacity for generating 3,000 kilowatts of electrical energy. In addition to these main units, there are also two exciter units and five transformers; each of the latter is capable of transforming 5,000 kilowatts from 2,300 volts to 66,000 volts.

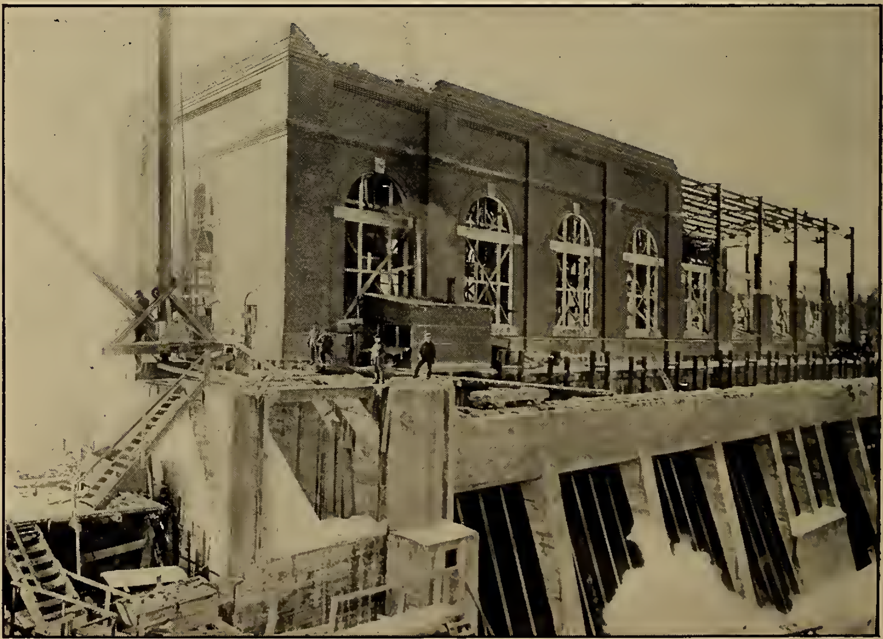
Cables carried on steel towers transmit this power. The transmission lines are run on private rights of way, 100 feet wide; the towers are about 60 feet high, and they stand 400 feet apart. Upon each tower there are stretched six heavy transmission cables, a telephone circuit and a guard wire. The towers, it is estimated, would require a pull of 11,000 pounds applied to their tops to overturn them; they are intended to stand the heaviest strain that will



THE 600-FOOT SPILLWAY BELOW BRATTLEBORO, MASS.

ever be put upon them. The insulators are 16 inches in diameter and 3 feet high, and each of them has a weight of almost 10 pounds.

These transmission lines will carry 20,000 horse-power with a loss of energy of less than 10 per cent. In order that mills may use the electric



VIEW OF THE POWER HOUSE UNDER CONSTRUCTION AND OF THE INTAKES

GENERAL VIEW OF THE DAM AND POWER HOUSE ON THE CONNECTICUT RIVER NEAR BRATTLEBORO, MASS.

STEEL TOWER CARRYING THE CABLES WHICH TRANSMIT THE ELECTRIC POWER

energy that is thus brought to their doors, it is necessary to lower the high line voltage by means of sub-stations, of which four have been erected on the transmission line that runs to Worcester, at Gardner, Fitchburg, Clinton, and at the Worcester terminus. The stations on this one line offer 75,000,000 kilowatt hours of energy a year at a rate which is held to be comparable with that for steam generated from coal costing $2 per ton.

In the two years that were required for the building of this dam the engineers had more than once to face serious difficulties. One flood washed away what was called Elmore's Island and carried it down the river. The crib was filled with ice and water several times. The first suspension bridge was swept away, and again the waters climbed to the planking of the floor of a new bridge which was built higher still. When the current was deepest it was estimated that there were 100,000 cubic feet of water swirling every second over the dam. Once the machinery had to be hoisted out of the coffer-dam at night.

Within reach of this dam by means of the transmission lines there are a large number of towns and cities: Worcester with 130,000 people, Springfield with 74,000, Lowell with 95,000, Manchester with 60,000, Fitchburg with 30,000, Pittsfield with 25,000, North Adams with 32,000, and such smaller places, ranging down to 5,000, as Brattleboro, Ware, Keene, Orange, Palmer, and others.

The engineers who constructed the dam were M. G. Chace and H. I. Harriman; the enterprise was financed by Baker, Ayling & Co., of Boston.

RECENT PROGRESS IN MOTORS FOR AEROPLANES

By W. F. Bradley

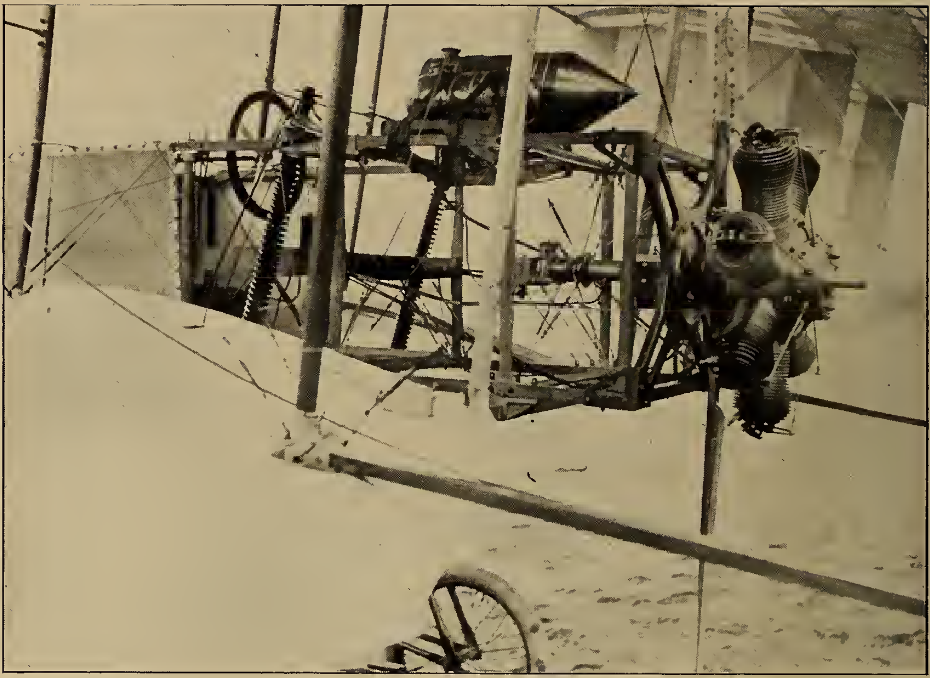
It is now conceded that much of the progress which has been made in aviation is due to the development of the light-weight, high-power gasoline motor. The experiments of the Wright Brothers in gliding, in America, and of Santos, Farman, and others, in France, could have resulted in little real progress had there not been available the motor which had been produced as a result of the work of Daimler and his followers in the production of motors for automobile service. Since the success of the aeroplane has been assured, the efforts of the motor constructors have been directed toward still further improvements as respects reduction in weight, greater assurance of reliability, and further efficiency in performance. Mr. Bradley discusses some of the latest developments in aeroplane motors, with illustrations of the productions of makers whose reputations are already assured.—The Editor.

DESPITE the conspicuous success of one totally unconventional type of motor for aeroplane work, the decided tendency among European builders is towards the standard type of gasoline motor lightened where the loss of metal cannot possibly entail loss of strength. The Wright brothers undoubtedly began the tendency with their four-cylinder motor of standard design in all its general features. Up to that time European makers had been endeavouring to obtain lightness by what they now term "jewelers' work," or by radical departures in design from what had previously been considered the most satisfactory type. Despite its indifferent workmanship and defects in detail, the first Wright motor introduced in Europe answered the purpose required of it, and the second series, built on the same design, but with all the facilities of a modern shop, together flew, it is calculated, about 6,000 miles with only three involuntary stops.

Convinced that there is a future for a medium-weight motor capable of running for hours under full load without any signs of weakness, practically every European automobile constructor has begun experiments on the lines indicated by the Wright brothers. Taken collectively, four-cylinder motors are in the majority for aeroplane work, though to obtain this majority about a score of different firms are involved. The greatest number of motors of any one make now being used on aeroplanes is undoubtedly the Gnome, a seven-cylinder, revolving, air-cooled type. This, however, is a prominent exception, for of all the attempts to obtain lightness and reliability by a distinct departure from standard lines the Gnome is the only one that has really succeeded.

The portion of the motor which has been most generally attacked as furnishing useless metal is the water-jacket. When cast with the cylinders it gives an amount of metal the weight of which is altogether disproportionate to the work it has to do, and, owing to the difficulty of accurate verification, necessitates leaving a greater thickness in the cylinder walls than safety demands. The Mutel is a good example of weight-reducing without impairing efficiency, the four cylinders being cast separately, turned inside and out to a uniform thickness of metal, mounted on an aluminum crank-case, and fitted with a one-piece sheet-metal jacket. A flange is fitted around the base of the cylinders and another one above the valve pockets on the heads, and it is to these two that the one-piece water-jacket is welded. The design, of course, gives a perfect circulation of water around the cylinders as well as around the valve chambers.

On the Buchet six-cylinder vertical motor the castings are in pairs, with only a framework water-jacket on



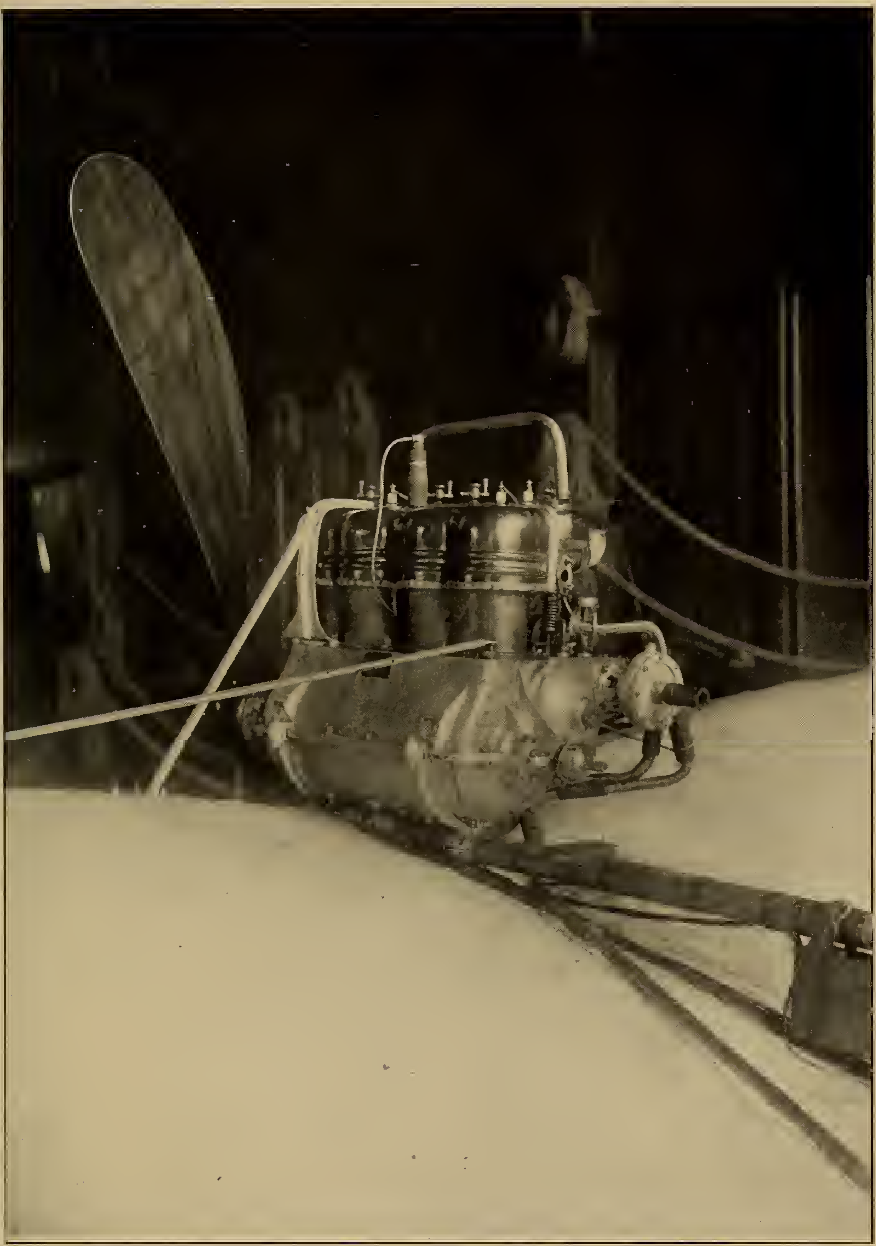
GNOME SEVEN-CYLINDER RADIAL MOTOR, AIR COOLED. THE ONLY FRENCH "FREAK" MOTOR WHICH HAS PROVED SUCCESSFUL

each side and the two ends. A suitable copper plate is screwed onto this frame, thus completing the water-circulating space. The reduction of metal is not quite so great as on the Mutel, but the system has the advantage of being one that conforms to standard workshop practice and offers no difficulty of realization. As in the previous case, the valves are carried side by side in the cylinder head.

The new four-cylinder motor manufactured by the Clement-Bayard Company is absolutely standard, with the exception of the water-jacket. The four cylinders are in one casting, with valves on one side in an outstanding port, but without a water-jacket. This is added afterwards in the form of copper covering profiled to the shape of the motor and ribbed to allow of dilation. It is riveted in position along the base of the combustion chamber, the two sides and along the head, just behind the valve pockets. Seen from the valve side, the motor has entirely the appearance of the ordinary type with valves in a pocket on one side. Seen from the opposite side, only a one-piece copper jacket is presented.

Panhard, one of the latest French firms to produce an aviation motor, has adhered to a design that has had the test of years of hard automobile racing experience. The four cylinders are of steel, with separate cast heads, and each equipped with a copper water-jacket. They are placed so close together on their crank-case that a continuous water-circulating space is formed, the only connection being a fibre-lined collar between each two cylinders. The distinctive feature of the motor is the valve mechanism, which will be described later.

Darracq and Clement-Bayard, both producers of two-cylinder horizontal motors for the Santos-Dumont and other similar types of small monoplanes, use a cast-steel cylinder with a welded-on copper water-jacket, valves being in the head. The

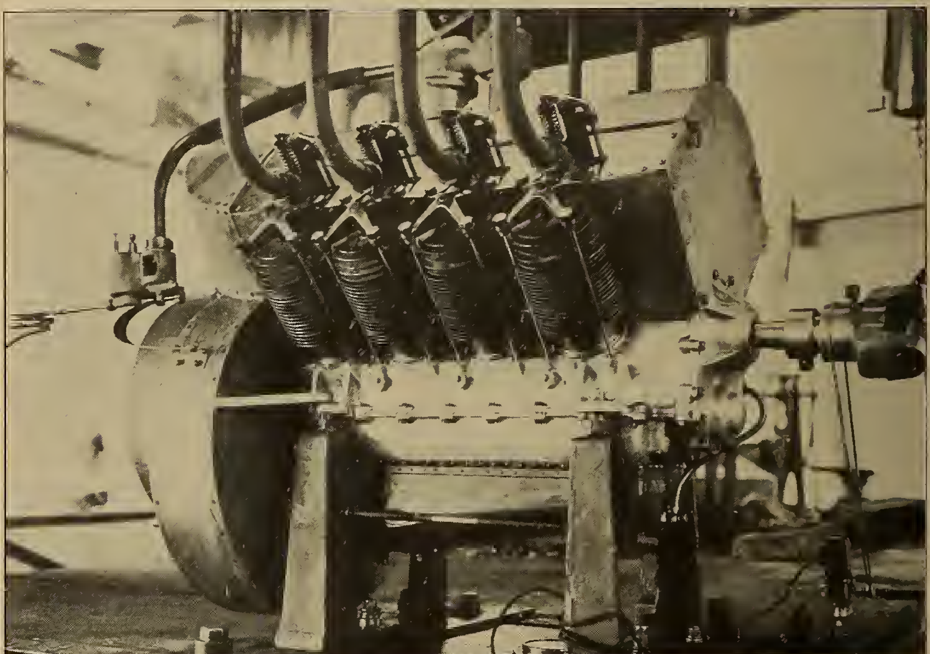


CLEMENT FOUR-CYLINDER MOTOR MOUNTED ON SANTOS-DUMONT'S "DEMOISELLE" MONOPLANE, SHOWING ALSO THE PROPELLER AND A PORTION OF THE PLANES

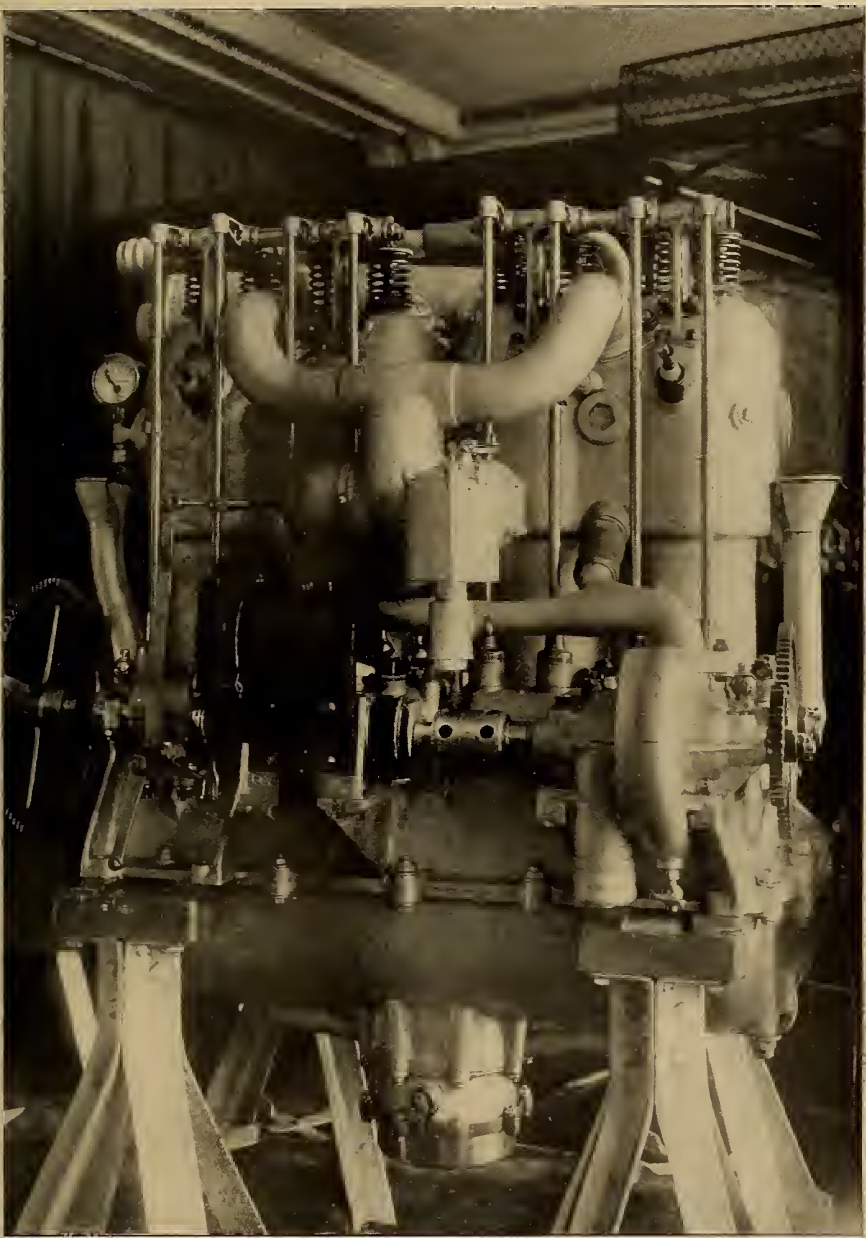
Mercedes, a four-cylinder motor inspired on the racing car type, is one of the few adhering to a cast water-jacket integral with the cylinders. Mors has a V-type four-cylinder motor, the water-jacket of which is distinctive by reason of the unusually large core openings, enclosed by light aluminum plates secured by six or eight bolts, according to their size.

There is a tendency to employ a hemispherical combustion chamber, carry large-diameter valves in the head, increase the ratio of stroke to bore, and augment the compression. The Mutel, Buchet and Mercedes are examples of this. On the Mutel the vertical push rods are light steel tubes and the rocker arms are as light as possible, while an advantageous feature is the entire accessibility of the valve mechanism. The Buchet, although similar in general features, differs by the manner in which the rocker arms are mounted. Being designed after racing car models, there is nothing about the Mercedes valves that calls for particular attention. The valves are in the head side by side, the four rocker arms being mounted on a common shaft for a pair of cylinders and carried in two vertical steel brackets drilled for lightness and bolted to the top of the cylinders.

Although the concentric valve is not new, there is a good deal of originality in the way it has been worked out for the Panhard aviation motor. It consists of an outer cylindrical exhaust valve, which also forms a guide for an ordinary large-diameter mushroom type inlet valve. The cylindrical stem of the exhaust valve is in two diameters corresponding with the borings of the separate head in which it is guided, and the space between these two diameters is cut away to form an entrance for the mixture to the inlet valve. The exhaust valve is guided at two different points, the lower large diameter portion and the upper and longer portion, within which is the guide for the inlet valve stem and the spring which operates it. The base of this longer cylinder is closed by a cap, offering a seating for the inlet valve spring, and the top is closed by a flanged cap receiving the upper end of the exhaust valve spring. On this cap is mounted a



RENAULT EIGHT-CYLINDER, AIR-COOLED MOTOR WITH ENCLOSED BLOWER FOR ASSISTING COOLING AND HEAVY CAMSHAFT MADE TO RECEIVE PROPELLER



THE NEW MERCEDES MOTOR, ONE OF THE FEW USING A CAST WATER JACKET

second and smaller rocker arm, at right angles to the main one, and employed to operate the inlet valve only. The main rocker arm has a forked end, the branches of the fork being of unequal length. On the rocker arm being raised by the operation of the cam, the exhaust valve is opened in the usual way, the inlet, of course, being carried down with it. On the return of the rocker arm, as the tappet follows the profile of the cam, the specially shaped forked end operates the second and smaller rocker from

PANHARD CONCENTRIC INLET AND EXHAUST VALVES, AND ROCKER ARMS MOUNTED ON THE CYLINDER HEADS

beneath, thus causing the opening of the inlet valve.

A distinctive feature is a special Y-shaped head casting, water cooled, and screwing into the head of the cylinder. One arm of the Y is bored out to receive the intake manifold, the opposite arm forms a bracket in which the specially shaped rocker arm is pivoted, and the centre or stem of the Y is bored out to receive the cylindrical stem valve. The mere fact that this type of valve has been adopted by a firm of the standing of Panhard should remove the suspicion of unreliability that has so long been attached to it.

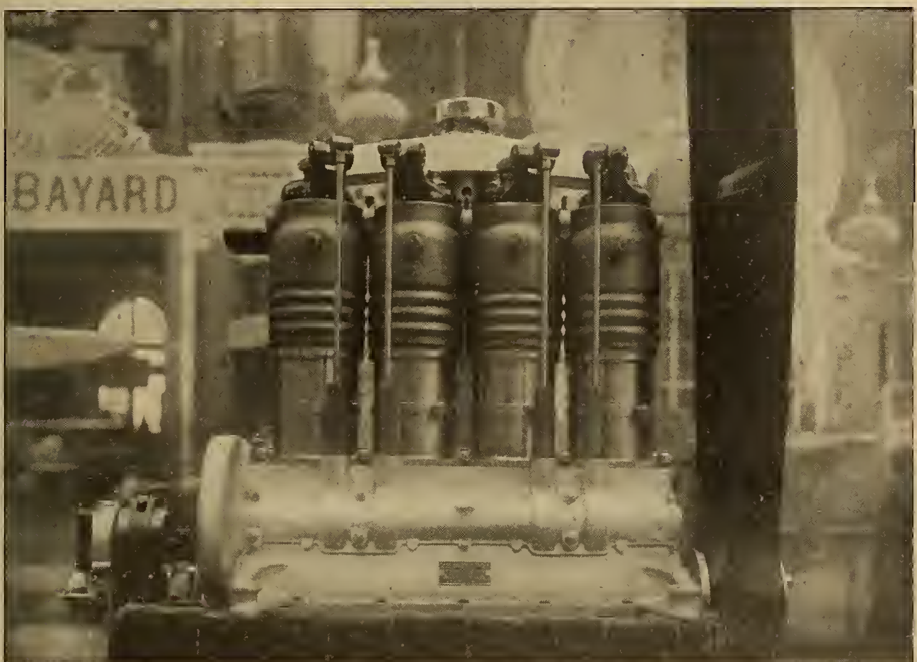
Pressed steel pistons, made as light as possible by reducing the thickness of metal, by limiting the length to the lowest limits compatible with proper guiding, or by drilling the lower portion, are to be found on nearly all the modern aero motors. An example of this is seen in the Buchet motor, in which the piston is both short and drilled. A similar design is employed on the Mutel, and in both cases the connecting-rod is designed to give the lowest weight possible. A certain amount of weight has been saved on the Mutel and the Mors motors by employing an aluminum crank-case without the usual longitudinal division, the only opening being at one end, through which the crankshaft is passed. As for aeroplane work, the dismounting of the motor generally entails total dismantling of the power plant, and the advantage of a detachable crankcase is not so great as in automobiles. The extra rigidity, with a smaller amount of metal, justifies the change.

Ignition is invariably by high-tension magneto only, without the use of accumulators as a stand-by for starting. Light-weight magnetos have been produced, but in most cases the ordinary car type is employed, the saving of a few ounces of weight in this direction not being advisable at the loss of efficiency. Carburetors, on the other hand, are of the standard design, but built of the lightest

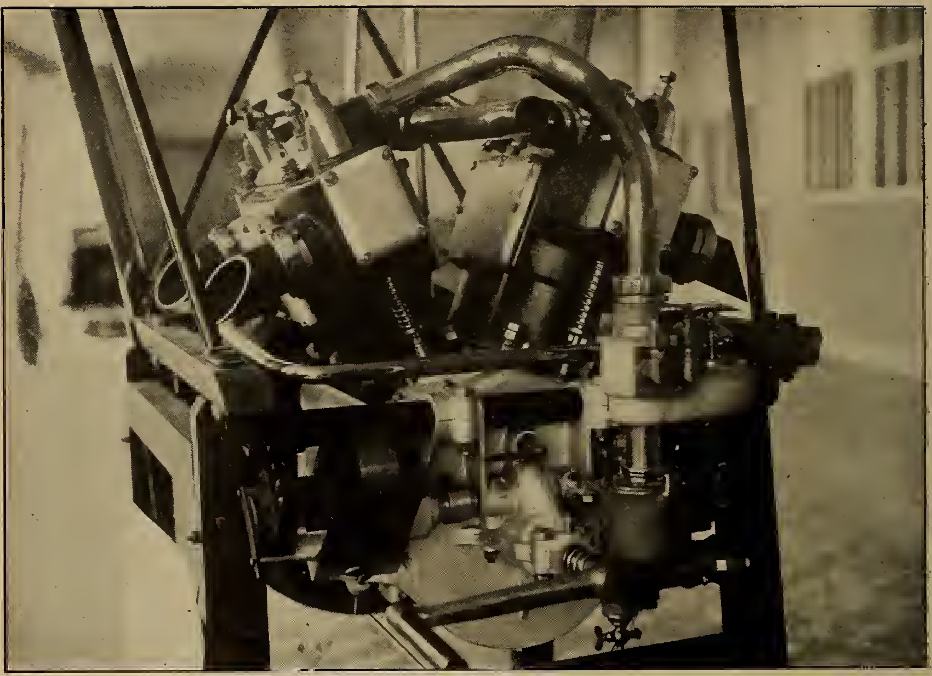
metals obtainable, aluminum being largely employed. In view of the fact that an aviation motor is constantly called upon to develop its full power, lubrication cannot be neglected. In the majority of cases this is of the forced-feed type to the crankshaft bearings and through internal channels to the connecting-rod ends, with the wrist-pins and cylinder walls supplied by splash. Cases in which the connecting-rods are made hollow to feed the wrist-pins are comparatively few.

It is hardly correct to place the Mors motor in the standard design class, for the four-cylinder V type is not common for automobile work. The difference, however, is more in details than in essentials, despite the unusual appearance of the motor. The cylinders are in pairs, mounted on an aluminum crank-case, and inclined only 30 degrees from the vertical. Usually on a motor of this type a two-throw crankshaft is employed, each throw receiving two connecting-rods corresponding to two cylinders diversely inclined. On the Mors a four-throw shaft is employed, as on an ordinary motor, with the difference that instead of the throws being in the same plane they are offset in relation one to the other just the same amount as the cylinders. The lack of balance thus set up is rectified by the use of internal balance weights. The advantage of the method is that it allows the motor to be fired by a standard type of four-cylinder, high-tension magneto.

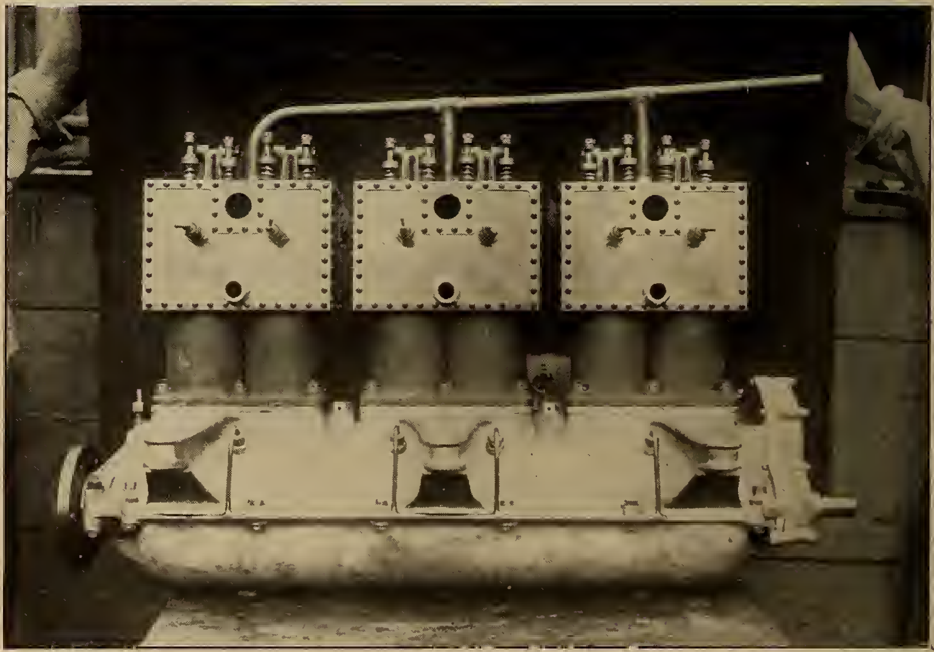
The valves are not in the angle of the cylinders, but at each end, the exhausts being operated from below and the automatic intakes mounted above them in a dome chamber. As variations of speed are not required for aeroplane work, the only real objection to automatic intakes does not hold here. Owing to the slight inclination of the cylinders, it is impossible to employ a camshaft within



PANHARD MOTOR WITH FOUR SEPARATELY-CAST STEEL CYLINDERS AND PRESSED COPPER JACKETS



MORS DISTINCTIVE V-TYPE MOTOR WITH INTEGRAL JACKETS AND LARGE CORE OPENINGS CLOSED BY ALUMINUM PLATES



BUCHET SIX-CYLINDER MOTOR, WITH CYLINDERS CAST IN PAIRS AND COPPER PLATES SCREWED IN PLACE TO FORM WATER JACKETS

the angle and parallel with the crankshaft. In its place are two small camshafts, one at each end of the motor, each driven from the crankshaft with the usual reduction.

A fly-wheel of large diameter and comparatively low weight is employed on the Mors. In a number of cases, however, the four-cylinder motors are run without any fly-wheel other than that provided by the propeller mounted on the main shaft. This is the case with the Clement motors, whether used on the firm's biplanes or the small "Demoiselle" monoplanes which Clement-Bayard are now manufacturing. The Mutel is generally run without a fly-wheel, and the six-cylinder Buchet is fitted with one only, if desired, by the builder of the aeroplane.

Mors is one of the first to fit an aeroplane motor with a starting crank and clutch, this latter being of the band type used on the Mors touring cars. The Clement Company employs a starting handle and clutch for use on its biplanes, but dispenses with both when the motor is used on the small monoplane. Voisin, who has recently brought out a four-cylinder motor with concentric valves, also uses a starting crank, without clutch and without fly-wheel.

Except the two-cylinder Darracq and the Clement-Bayard, especially designed for small monoplanes, all the motors described are intended to develop from 45 to 50 horse-power, this being the most durable power for the majority of biplane flying machines. The greatest ratio of stroke to bore is found on the six-cylinder Buchet, the dimensions of which are 100 millimetres by 150 millimetres. The others, all four-cylinder motors, are: Mutel, 120 by 166; Panhard, 110 by 140; Clement, 100 by 120; Mors, 110 by 130, and Mercedes, 100 by 140.

Attempts to find a suitable reducing gear between motor and propeller have not been very successful, if exception is made of chain drive. The only French machine of any importance using a chain is the No. XII. Bleriot, in which the motor is on the lower portion of the framework and the propeller shaft is carried in bearings nearly 4 feet above it. Farman experimented with a reducing gear in connection with a Gnome motor, an internal spur gear being mounted to the revolving crank-case and meshing with a pinion on the propeller shaft. The attempt had to be abandoned, however, owing to the difficulty of properly lubricating the gears. For its new type of biplane the Clement-Bayard Company transmits from the motor through a propeller shaft with universal joint at each end to a gear set mounted in floating bearings. The small gear box is carried in an outbuilt triangular frame to the rear of the wings, and is purposely left with a certain amount of freedom. It appears to be satisfactory, but a sufficiently long trial has not yet been made to warrant a definite pronouncement. The Renault firm has employed very successfully the camshaft for carrying the propeller, thus obtaining a two-to-one reduction without the use of additional gears. The camshaft is of equal diameter to the main shaft; it is mounted in three bearings, and the timing gears are, naturally, of a size and strength altogether unusual in this portion of the motor. Maurice Farman has made a number of long flights with a 7-foot wooden propeller mounted on the camshaft without any weakness developing in the mechanism of connections.

THE MECHANICAL HANDLING OF SMALL MATERIALS

By George Frederick Zimmer, A. M. Inst. C. E.

CONVEYORS of almost all known constructions are suitable for the mechanical handling of such materials as minerals, coal, coke, stone, clinker, gravel, seeds or cereals and oil seeds and nuts, but small materials such as cement, plaster of Paris, fine sand, and the powders produced by grinding or crushing of the first named substances, as well as other powders such as flour, sugar, salt and spices, are all more or less difficult to handle, and indeed only a limited number of conveyor types can be used for this purpose, and then often only with indifferent success.

The reasons why fine material is so much more difficult to handle than coarse are various, and one of the principal is the production of dust at the slightest agitation, so that a conveyor which moves the material by a stirring, pulling or pushing device must be enclosed, so as to prevent dust and loss. Even with conveyors which perform their functions without this agitation and in which the material is carried as it is on a belt conveyor, the usual high speed at which these conveyors work will create dust by the resistance of the air to the passage of the material.

There are also other difficulties, caused by the great difference in the consistency of fine materials. Some are of a lively nature and run through your fingers if you try to get a handful, and this class of stuff wants a close-fitting conveyor, say of the push-plate or worm type, for its handling, as on a belt conveyor there is a great tendency for it to run off, unless the belt is well troughed. Other fine materials are of just the opposite consistency, almost dead as, for instance, cement, which if conveyed in a push-plate conveyor have a tendency to lie at the bottom of the trough and let the scrapers travel over the top.

Then, again, there is a difficulty in handling fine materials on account of the tendency of fine particles to enter the working parts of the conveyor, and if the material is of a sharp and cutting nature this is one of the principal drawbacks, as such parts are soon destroyed by wear and tear.

It will thus be seen that for the conveying by mechanical means of fine materials the utility of the existing types of conveyors is considerably restricted. Belt conveyors can be used if the material can be fed on and off without causing dust and also if the belt travels sufficiently slowly. Whilst all conveyors with agitators can only be used when running extremely slowly or when completely covered in, this is sometimes difficult, particularly with push-plate conveyors, the general construction of which would not permit of covering without complications.

The Zimmer conveyor of reciprocating type appears to be very suitable for handling fine material because the trough can easily be covered with a dust-tight lid, and there are no stirring or pushing elements to create dust or which are subject to wear; but again there is an objection, and that is that with this type of conveyor fine material can only be conveyed satisfactorily in a very thin layer or stream, and then preferably on a slightly downward gradient, so that here the same objection holds good as with the belt conveyor. Both can be made to do the work, but the capacity is small on the belt conveyor on ac-

count of the slow speed, and on the Zimmer conveyor on account of the thin feed, so that both these types if used for fine material would have to be made rather wider, and, therefore, more expensively, for capacities which could be conveyed on smaller conveyors if the material was coarse.

As a résumé of the foregoing, push-plate, belt and Zimmer conveyors cannot be looked upon as the best means of handling this material under general conditions, so there is only the worm conveyor left. This can be fitted with a dust-tight lid and inlets and outlets, and it has a moderate capacity. It does the work well if the material is not of a cutting nature, and is inexpensive in first cost, but for long distances and large capacities it presents drawbacks which make it not much better than the other types. The driving power consumed is higher than that of any other conveyor, and with sharp and cutting stuff the wear and tear on the ordinary intermediate bearings, which must of necessity work surrounded by the material to be conveyed, is tremendous.

The worm or Archimedean screw is undoubtedly the oldest type of conveyor, and it has been the only appliance for the mechanical conveying of such fine materials, and this simple mechanism, with all its good and bad points, has been practically unsurpassed till quite within recent years.

The history of the worm conveyor is difficult to trace, and it is probable that the flour miller was the first user of this labour saver. Whatever purpose the worm conveyor might have served in earlier times, we know for certain that a crude form of it was employed in flour mills over 250 years ago.

The nature of the worm conveyor is such that only comparatively fine material can be conveyed satisfactorily, and at the time when this conveyor was the only appliance for conveying, all materials consisting of pieces too large for this type of conveyor were debarred and had to be moved by hand labour.

Worm conveyors are of the simplest possible construction. They consist of a continuous or broken-bladed screw fixed to a revolving spindle, and the whole is mounted in a suitable trough, so that the revolving screw propels the material fed in at one end of the trough to the other end. There is a small space between the screw and the trough; this should be either as small as possible, or just a little larger than the size of the largest piece contained in the material to be conveyed, as if fractions of the material are larger than the space they become wedged between the screw and the trough and thereby may cause stoppages.

Well-made worm conveyors, with well-fitting troughs, i. e., not too tight, of sufficient rigidity so as not to require too many intermediate bearings, with the latter of a design so as not to obstruct the flow of the material, are undoubtedly good and serviceable conveyors for all flour-mill products, meal, seeds, cereals, cattle food, crushed seed cakes, etc., material used in the manufacture of linoleum, such as cork powder and sawdust, and as a matter of fact for all fine materials which are not gritty or cutting, always provided the worms are not too long and are not required for too large a capacity.

Worm conveyors of the continuous, paddle or spiral types are made with diameters of from 4 inches to 18 inches and even more, but those of 12 inches and over, except for short distances, of, say, not exceeding 40 to 50 feet, and for the materials just mentioned, can hardly be called satisfactory. As to the worms of the smaller diameters and for the same materials, lengths not exceeding 150 feet for 4-inch to 8-inch worms, and 100 feet for 9-inch to 10-inch, should be the limit of their practical utility.

It is true that there are installations to be found in which these limits are exceeded, but they cannot be called economical. In the end it comes to this, that for really heavy work of this class there has not been a suitable con-

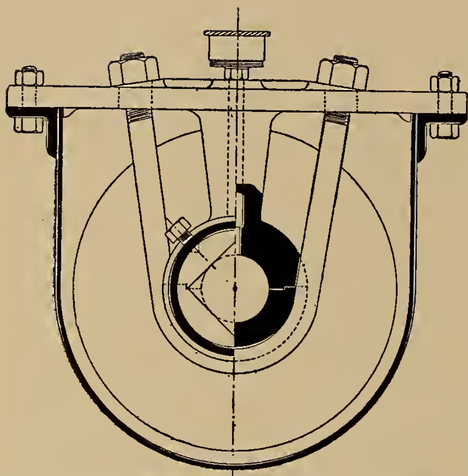


FIG. 1.—CROSS SECTION OF WORM CONVEYOR BEARING

veyor and worms were used because there was nothing better.

With reference to the pitch of worm conveyors, this differs very much, say from one-quarter of the diameter to a pitch equal and even greater than the diameter of the worm.

The pitch is determined by the nature of the material to be conveyed and by the construction of the worm. For materials such as cement and other specifically heavy and cutting substances a small pitch is most essential, and for such substances it is most advantageous to employ continuous or close-bladed conveyor of a pitch of, say, equal to half the diameter. The following table gives the sizes and capacities of such small pitched continuous or close-bladed worms.

Close-bladed or continuous worms are also made with a larger pitch for lighter material, generally with a pitch of about two-thirds their diameter. These answer their purpose well, as the capacity of these continuous conveyors is nearer the theoretical capacity than is the case with open spirals or with paddle worms. The reason why closed-spiral worms are not often made with a pitch more than two-thirds to three-quarters their diameter is that it is difficult to bend or roll the blades to a large pitch, but even then their relatively large capacity bring these up in capacity to nearly that of paddle and open spirals of a larger pitch.

The driving power required for worm conveyors depends mostly upon the weight of the material to be moved and the distance to which it has to be conveyed. The type of the worm, its diameter and speed, enter to a smaller degree into the calculation. It will, therefore, be a sufficient guide to give two tables, one for light and one for heavy materials, from which the ap-

Diameter of worm in inches	4	6	8	9	10	12	14	16	18
Pitch of worm in inches	2	3	4	4 1/2	5	6	7	8	9
Outer diameter of hollow spindle in ins.	1 3/8	1 15/16	1 15/16	2 3/16	2 7/16	2 7/16	2 15/16	2 15/16	2 15/16
Diameter of internal bearings and end gudgeons in inches	1	1 1/2	1 1/2	1 3/4	2	2	2 1/2	2 1/2	2 1/2
Revolutions per minute	130	120	100	100	90	90	80	70	60
Capacity in cubic feet per hour	30	60	180	250	300	600	900	1000	1300

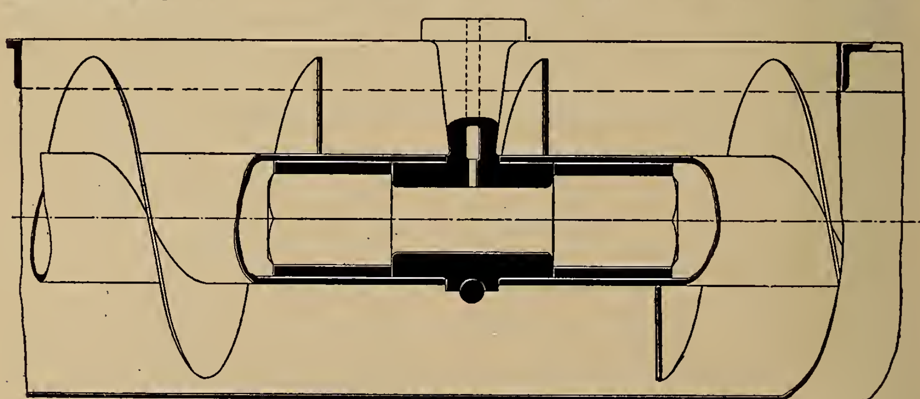


FIG. 1A.—LONGITUDINAL SECTION OF WORM CONVEYOR BEARING

TABLE GIVING APPROXIMATE HORSE-POWER REQUIRED TO DRIVE A WORM CONVEYOR FOR GRAIN OR OTHER LIGHT MATERIAL

Tons per Hour.	Length of Conveyor in Feet. 10	20	30	40	50	60	70	80	90	100
5	0.19	0.38	0.57	0.76	0.95	1.14	1.33	1.52	1.71	1.90
10	0.38	0.76	1.14	1.52	1.90	2.28	2.66	3.04	3.42	3.80
15	0.57	1.14	1.71	2.28	2.85	3.42	3.99	4.56	5.13	5.70
20	0.76	1.52	2.28	3.04	3.80	4.56	5.32	6.08	6.84	7.60
25	0.95	1.90	2.85	3.80	4.75	5.70	6.65	7.60	8.55	9.50
30	1.14	2.28	3.42	4.56	5.70	6.84	7.98	9.12	10.26	11.40
35	1.33	2.66	3.99	5.32	6.65	7.98	9.31	10.64	11.97	13.30
40	1.52	3.04	4.56	6.08	7.60	9.12	10.64	12.16	13.68	15.20
45	1.71	3.42	5.13	6.84	8.55	10.26	11.97	13.68	15.39	17.10
50	1.90	2.80	5.70	7.60	9.50	11.40	13.30	15.20	17.10	19.00

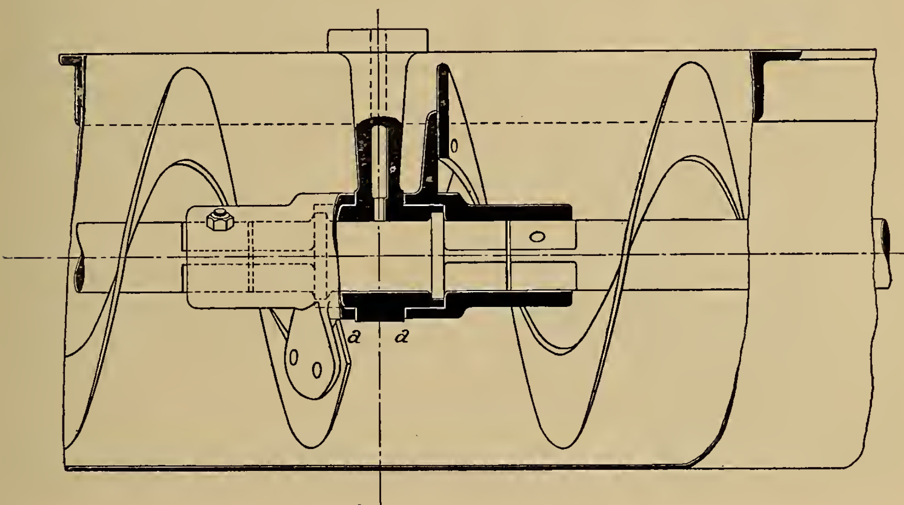


FIG. 2.—DUSTPROOF CONVEYOR BEARING MADE BY THE CONVEYOR & ELEVATOR CO., ACCRINGTON, ENGLAND

proximate horsepower can be found.

Worm conveyors for fine cement and similar materials are frequently built on somewhat different lines, and the tendency is to use more particularly the continuous or closed spiral. The principal differences are the use of a rather larger trough, for instance, an 11-inch trough for a 10-inch worm. This allows of a ½-inch space between the movable worm and the stationary trough, so that the cement in the worm will form its own trough within the iron trough, and that there is no wear on the trough itself at all. This arrangement causes, however, more wear on the periphery of the worm spiral, which thereby gradually becomes smaller in diameter.

In one of the largest cement works on the lower Thames, where miles of these worms are in use, the practice is as follows: Ten-inch continuous worms fitted in 11-inch troughs with the bearings 10 feet apart and with a pitch of 7 inches and a speed of 80 revolutions. These worms convey 7, 14 and sometimes even 21 tons of fine

TABLE GIVING THE APPROXIMATE HORSE-POWER REQUIRED TO DRIVE A WORM CONVEYOR FOR HEAVY MATERIAL

Tons per Hour.	Length of Conveyor in Feet. 10	20	30	40	50	60	70	80	90	100
5	0.33	0.66	0.99	1.32	1.65	1.98	2.31	2.64	2.97	3.30
10	0.66	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.60
15	0.99	1.98	2.97	3.96	4.95	5.94	6.93	7.92	8.91	9.90
20	1.32	2.64	3.96	5.28	6.60	7.92	9.24	10.56	11.88	13.20
25	1.65	3.30	4.95	6.60	8.25	9.90	11.55	12.40	14.85	16.50
30	1.98	3.96	5.94	7.92	9.90	12.28	13.86	15.84	17.82	19.80
35	2.31	4.62	6.93	9.24	11.55	13.86	16.17	18.48	20.79	23.10
40	2.64	5.28	7.92	10.56	13.20	15.84	18.48	21.12	23.76	26.40
45	2.97	5.94	9.81	11.88	14.85	17.82	20.79	23.76	26.73	29.70
50	3.30	6.60	9.90	13.20	16.50	19.80	23.10	26.40	29.70	33.00

FIG. 3.—SUESS CONVEYOR, 250 FEET LONG, CONVEYING FINE CEMENT

TABLE GIVING DIAMETER, PITCH AND CAPACITY OF THE CONTINUOUS OR CLOSE-BLADED WORM OF THE MORE USUAL CONSTRUCTION

Diameter of Worm in Inches.	Pitch of Worm in Inches.	Outer Diameter of Hollow Spindle in Inches.	Diameter of Internal Bearings and End Gudgeons in Inches.	Revolutions per Minute.	Capacity in Cubic Feet per Hour.	Length Between Bearings.
4	4	1 5/16	1	130	70	8 feet
5	5	1 5/8	1 1/4	120	100	
6	6	1 7/8	1 1/2	120	175	
7	6	1 7/8	1 1/2	110	250	
8	6	1 7/8	1 1/2	100	300	10 feet
9	8	2 3/8	2	100	400	
10	8	2 3/8	2	90	500	
11	10	2 3/8	2	90	650	
12	10	2 3/8	2	90	850	12 feet
13	10	2 15/16	2 1/2	80	1,000	
14	10	2 15/16	2 1/2	80	1,200	
15	12	2 15/16	2 1/2	70	1,350	
16	12	2 15/16	2 1/2	70	1,550	
18	12	2 15/16	2 1/2	60	1,800	

cement per hour. As these conveyors are all driven by electric motors the actual power consumed can easily be ascertained, and from a number of readings the average power was 1 brake-horsepower for every 35 feet of conveyor when handling 7 tons of cement.

The intermediate bearings are similar to Fig. 1, from which it will be seen that the space between the different sections of the 10-inch worm is very small, only 1½ inches; this is a great advantage, as the break of the blades at the junction is very small, which prevents accumulations. These bearings have also the further advantage that the working portions are quite away from the injurious influence of the cement.

TABLE GIVING DIAMETER, PITCH AND CAPACITY OF THE OPEN-BLADED OR SPIRAL CONVEYOR FOR HEAVY, AS WELL AS FOR LIGHT, WORK

Diameter of Spiral n Inches.	Pitch of Spiral in Inches.	Diameter of Solid Shaft. Inches.	Section of Spiral. Inches.	Speed for Heavy* Materials, Revolutions per Minute.	Capacity for Heavy Materials in Cubic Feet per Hour.	Speed for Light† Materials. Revolutions per Minute.	Capacity for Light Materials in Cubic Feet per Hour.
4	4	1¼–1½	1¼ x 3/16	100	40	130	60
6	5	1½	1½ x 3/16	90	120	120	150
8	6	1½–2	1¾ x ¼	80	230	110	300
10	7	2 –2½	2¼ x ¼	70	350	100	500
12	8	2 –2½	2¼ x ¼	60	550	90	800
14	9	2½–3	2½ x ¼	60	700	80	1,100
16	10	2½–3	3 x ¼	50	950	70	1,400
18	11	2½–3	3½ x ¼	40	1,100	60	1,700
20	12	2½–3	3½ x ¼	35	1,300	50	1,900
22	13	3 –3½	3½ x ¼	30	1,500	40	2,100
24	14	3 –3½	3½ x ¼	25	1,600	35	2,300

TABLE GIVING DIAMETER AND CAPACITY OF PADDLE WORMS

Diameter of Worm. Inches.	Pitch of Worm. Inches.	Outer Diameter of Hollow Spindle. Inches.	Diameter of Intermediate Bearings and End Gudgeons. Inches.	Diameter of Shank of Blade. Inches.	Speed for Heavy* Materials. Revolutions per Minute.	Capacity for Heavy Materials. in Cubic Feet per Hour.	Speed for Light† Materials. Revolutions per Minute.	Capacity for Light Materials. in Cubic Feet per Minute.
4	4	1 3/8	1	5/16	85	26	120	40
5	5	1 5/8	1¼	5/16	85	65	120	90
6	6	1 11/16	1½	3/8	80	110	110	170
7	7	1 11/16	1½	3/8	80	175	110	260
8	8	1 11/16	1½	½	70	220	100	330
9	9	2 3/16	1¾	½	70	320	100	470
10	10	2 3/8	2	½	60	400	90	600
11	11	2 ¾	2¼	½	60	500	90	750
12	12	2 15/16	2½	5/8	60	600	90	900
14	14	2 15/16	2½	5/8	55	1,000	80	1,300
16	16	3 ½	3	5/8	50	1,350	70	1,800
18	18	3 ½	3	5/8	50	....	60	....

* Heavy materials include fine coal, cement, sand, ground minerals, fine gravel, plaster of Paris, oxide of iron, etc.

† Light materials include grain, seeds, sugar, flour, meal, bran, ice, sawdust, rice, etc.

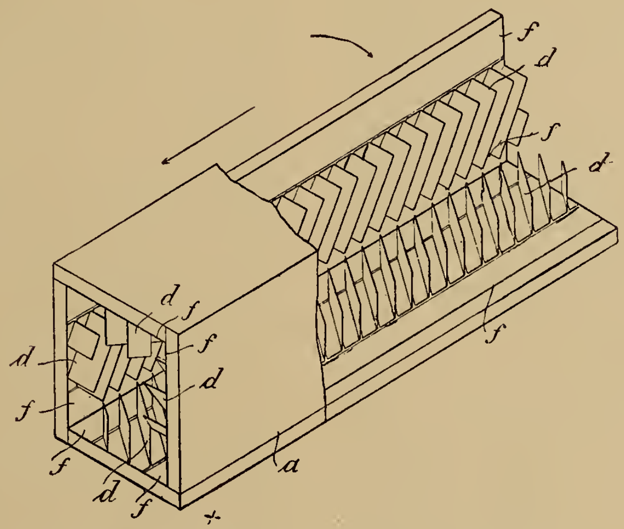


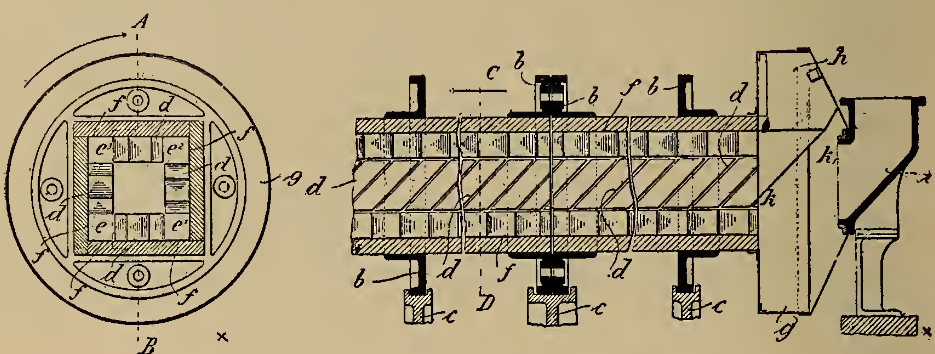
FIG. 4.—PERSPECTIVE VIEW AND PART SECTION OF SUESS TUBE CONVEYOR

Fig. 2 is a similar type of bearing, for which it is claimed that it is perfectly dustproof. It is the design of the Conveyor & Elevator Company, of Accrington. These bearings are lubricated by a viscous grease which is forced right through the bearing surfaces, so that the grease forms a dust collar round the surfaces *a a*.

The first step in the direction to provide a more economical and serviceable conveyor for fine material has been the introduction of the tubular or internal worm. This consists of a cylindrical tube with a continuous spiral fitted to its inner periphery. When at work it revolves bodily round an imaginary axis, being supported outside by suitable rollers.

The conveying action is not, as with the ordinary worm, a pushing forward, but the material is propelled by gravity, inasmuch as through the revolution of the tube the material contained in it is carried up the side in the direction of the revolution until it is compelled to fall back, when it is guided in a slightly forward direction by the spiral attached to the inside of the tube.

The capacity of this tube conveyor is not very large, as the pitch of the screw must be smaller than with most ordinary worms, say about one-third of the inner diameter of the tube, and the number of revolutions is also limited, as the centrifugal force, which comes into action as soon as the speed limit is exceeded, counteracts the propulsion, which is by gravity. It is thus obvious that the greater the pitch of the screw the greater the tendency of the material to cling to the inside of the tube, which tendency is still further encouraged when the centrifugal force begins to exert itself, so that a point is reached where the material is carried too far up the side of the tube, and there is then a tendency for it not to slide forward in its appointed channel but to fall, more than slide, back from its higher position, and so some of the material may fall back into the previous thread of the screw, which reduces the capacity more and more as the speed is increased, and eventually the centrifugal force being greater than the gravity, the material revolves round and round on the inner periphery of the tube and conveying ceases altogether.



FIGS. 5 AND 6.—CROSS AND LONGITUDINAL SECTION OF SUESS TUBE CONVEYOR

The speed at which tube conveyors should run may therefore be slightly slower for a larger pitch of the screw and vice versa. The following table gives the most suitable pitch and speed, also the capacity of cylindrical tube conveyors of different diameters.

A decided improvement on the tube conveyor is the Suess conveyor. It consists of a tube of rectangular section made either of sheet steel or wood. To the four inner sides of this tube are attached oblique blades forming an unbroken sequence of oblique channels on each side and for the whole length of the conveyor. These

Diameter of Tube in Inches.	Most Suitable Pitch in Inches.	Most Suitable Speed Revolutions per Minute.	Capacity Cubic Feet per Hour.
6	$2\frac{3}{8}$	80	40
8	3	75	100
10	4	70	200
12	$4\frac{3}{4}$	60	300
14	$5\frac{1}{2}$	55	350
16	$6\frac{3}{8}$	50	550
18	7	45	700
20	8	40	900
22	$8\frac{3}{4}$	35	1,000
24	$9\frac{1}{2}$	20	1,100

blades do not extend across the whole sides of the tube, but are only half as wide as the sides, so as to keep four longitudinal channels quite unobstructed by blades in the corners of the tube. For example, a 12-inch tube (inside measurement) has blades on each side 6 inches wide, so as to leave a space of 3 x 3 inches in each corner and for the whole length of the conveyor.

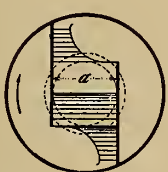


FIG. 7.—ENCLOSED CONVEYOR OUTLET

When at work, the action is as follows, supposing the whole of the material in the conveyor rests all along one of the corners. As this corner slowly moves upwards, the under side of the tube changes its horizontal position for a slanting one, and as soon as the angle is sufficiently steep the whole of the contents of the corner is forced by the law of gravity to slide across the oblique channels into the next corner, and in doing this it travels forward by the pitch of the channels or blades. This process repeats itself four times in every revolution. The very considerable slope of 45 degrees can be given to the blades, so that with each quarter revolution in a 12-inch tube the material moves theoretically 6 inches forward, or 2 feet with every revolution. This is practically equal to a 12-inch worm with a 24-inch pitch, if it was possible to make such a worm of the ordinary continuous type, which can not be done on account of the difficulty and expense to bend the blades to such a pitch, and for that reason a square tube like the Suess has a much larger capacity than a round cylinder of the same diameter.

With the Suess conveyor a single internal screw formed of four blades would not give a very positive result, as only part of the material would follow the oblique path, and in order to get the highest efficiency, the oblique blades are placed at such a distance apart as to form a five-fold or five-threaded screw, so that practically every particle is forced forward in its appointed channel.

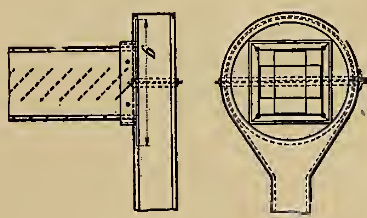


FIG. 8.—END OUTLET

The conveyor is made in lengths of from 15 to 20 feet and joined together with flanges. These are turned on the face and are used as supports for the conveyor, which rests on a series of pairs of rollers. The rollers are provided with flanges so as to prevent end movement. There is also a flexible packing ring between each pair of couplings, so that a slight variation from the straight line in the erection is not detrimental.

The driving pulley is made in halves with a square opening to fit the square tube, and this can be attached at any point in the length of the conveyor, whichever may be most conveniently situated in relation to the driving power.

Conveyors of this design have been built and are successfully at work in lengths of 250 feet. Fig. 3 shows such a conveyor in a cement works.

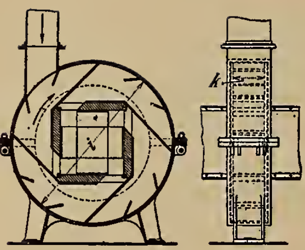


FIG. 9.—INTERMEDIATE INLET

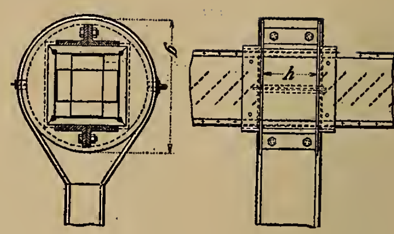


FIG. 10.—INTERMEDIATE OUTLET

As this tube conveyor is very rigid, it can also be used for transmitting a limited amount of power, so that at the extreme end, or in any desired position, power may be taken off by fixing a pulley, similar to the main driving pulley, concentrically on to the tube, for driving small auxiliary conveyors, or even elevators. This is sometimes of great convenience.

Fig. 4 represents a perspective view and part section of such a conveyor, and Figs. 5 and 6 show cross and longitudinal sections of the same. The illustrations show a wooden tube with metal channels. *d* represents the oblique blades, e e^1 e^2 e^3 show the longitudinal channels in the four corners as described above. The spaces *f f* can be covered over with sheet iron. *g* is the filling apparatus which revolves with the tube and has lifters which scoop up the material fed into the fixed inlet *i* and deliver it into the conveyor tube. *k* and k_1 show the slope at which the material is delivered into the tube. *b* are the ring supports to be used when further supports are desirable in addition to, or instead of, the flange coupling supports. These ring supports *b* are also employed in such positions where at times a portion of the conveyor has to be thrown out of work. For instance, if a conveyor of 100 feet total length has to deliver for a lengthy period at a point 50 feet from the feed end, half the conveyor can be disconnected simply by taking the four bolts out of the nearest coupling, and in order to do so a ring *b* should be near to such a point so as to carry the tube ends. *c* are the rollers on which the ring *b* or the flange coupling are supported.

The delivery at the opposite end can be either open, so that the material simply drops out, or it can be enclosed, which is preferable, so as to prevent dust. Such an enclosed end outlet, as well as intermediate inlets and outlets, are shown in Figs. 7, 8, 9, 10 and 11. These intermediate inlets and outlets are easily understood from the illustrations, the former having four lifters which collect and deliver into the tube any material fed into the inlet, and yet when there is no material added at any of these intermediate inlets the flow of the material passing by is not obstructed.

The intermediate outlet is a little more complicated, as it contains a loose piece of the tube with its channels, which must be removed before it

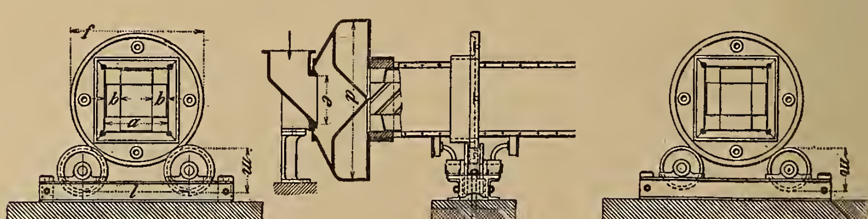


FIG. 11.—END INLET

will act as an outlet, but the change can be effected in a very few minutes. The loose piece is shown in the illustration.

It will thus be seen that the Suess tube conveyor can be fed from any number of points, and that the material can be withdrawn at any convenient point or points. It is therefore most useful, for instance, for feeding rows of silos or bins either one at a time or simultaneously. Fig. 12 shows another Suess conveyor driven by a pair of jockey pulleys.

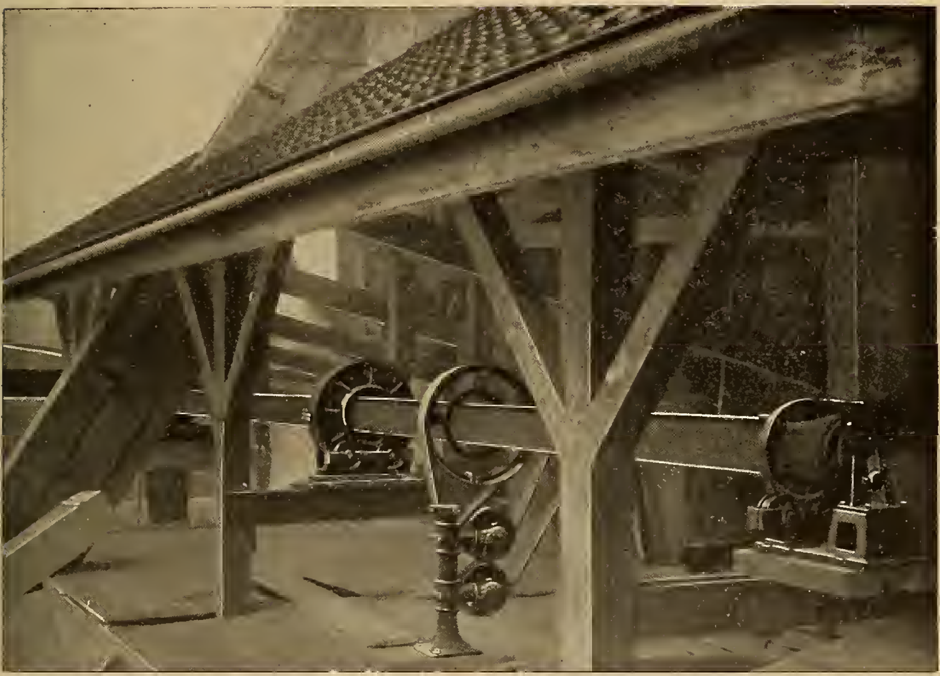


FIG. 12.—SUESS CONVEYOR, SHOWING METHOD OF DRIVING BY MEANS OF GUIDE PULLEYS

The lettering of Figs. 7 to 11 correspond with the dimensions given in the table for Suess conveyors of the three principal sizes in inches; the letter *c* in the table represents the pitch of the oblique blades, which stand at an angle of 45 degrees to the axis of the conveyor and at an angle of 75 degrees to their base at the side of the tube.

Size Number.	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*k*	*l*	*m*
1	7	1¾	2½	20	7	20	20	6	18	7	16	6
2	9½	2⅜	3	20	7	20	20	8	20	7	16	6½
3	12	3	3¾	24	8	24	24	10	24	8	18	7

The following table gives the capacity of the Suess conveyor for the three sizes in tons per hour of Portland cement, at the different speeds:

TABLE GIVING CAPACITY OF SUESS TUBE CONVEYOR.

Revolutions per Minute.	Capacity in Tons of Portland Cement per Hr No. 1	No. 2	No. 3.
10	1.2	5.4	8.37
15	2.04	7.2	12.555
20	2.88	9.	16.74
25	3.72	10.8	20.925
30	4.56	12.6	25.11
35	5.4	14.4	29.295
40	6.24	16.2	33.48
45	7.08	18.	......
50	7.92	19.8	......
55	8.76	....	......
60	9.6	.....	.....

RECENT DEVELOPMENTS IN SHIPBUILDING

By Benjamin Taylor

THE production of new vessels in the world in 1909 was 2,605 ships, of 2,287,752 tons and 2,616,752 I. H. P. This, comparing with 2,883 vessels, 2,275,354 tons and 2,131,214 I. H. P. in 1908, shows so small an increase in tonnage that we may call it stationary. The product of the United Kingdom in 1909 was 1,181,528 tons, of the British Colonies 6,419 tons, and of foreign countries 1,088,799 tons. These figures are taken from makers' returns and they differ from Lloyd's.

Lloyd's Register of British and Foreign Shipping reports that during 1909, exclusive of warships, 526 vessels, of 991,066 tons, were launched in the United Kingdom. The warships launched at Government and private yards numbered 42, and were of 126,230 tons displacement, making a total for the year of 568 vessels of 1,117,296 tons. The output of mercantile tonnage shows an increase of 61,397 tons on that of the previous year; but, with the exception of that of 1908, it is the lowest recorded by the society for twelve years. Practically the whole of the tonnage was of steel, and 98⅛ per cent. was steam. Of the total, 75 3-5 per cent. was for United Kingdom registry, and the net increase on the United Kingdom tonnage as a result of the year's additions and deductions was about 27,000 tons. The smallness of the increase as compared with previous years is accounted for by the breaking up of a large amount of old tonnage. There was launched for other countries 241,845 tons of new shipping—about 24 3-5 per cent. of the total, as compared with 40 per cent. in 1908 and 34 per cent. in 1907. British colonies, as in 1908, provided the largest amount of work for home yards, 70 vessels, of 60,027 tons, having been launched for colonial owners. The Glasgow district occupies first place among the principal shipbuilding centres of the country, showing an output of 204,451 tons. Then follow Newcastle, Greenock, Sunderland, Belfast, Middlesbrough and Hartlepool in this order. Among other countries, the United States is first, with 209,604 tons; Germany second, with 128,696 tons; Holland third, with 59,106 tons, with Japan, France and Italy following in this order. The returns show a considerable decrease as compared with 1908 in the case of nearly every country. This is especially noticeable in France (over 49 per cent.), Germany (nearly 40 per cent.), and the United States (over 31 per cent.). On the other hand, the tonnage launched in the United Kingdom shows an advance of 61,397 tons (or 6.6 per cent.) on the output for 1908. Of the tonnage launched, the United Kingdom acquired nearly 47 per cent. Of the total merchant tonnage output of the world during 1909, nearly 62 per cent. was launched in the United Kingdom; but, if only seagoing merchant steamers of 3,000 tons gross and upwards be taken into account, out of the total of 180 such steamers of 892,078 tons launched in the world nearly 75 per cent. of the tonnage has been launched in the United Kingdom. The total output of the world during 1909 (exclusive of warships) was, according to Lloyd's, 1,602,057 tons (1,537,570 steam and 64,487 sail), and the net increase of the world's mercantile

tonnage at the end of 1909 was about 734,000 tons. Sailing tonnage has been reduced by 199,000 tons, while steam tonnage has increased by 933,000 tons. Of the vessels launched during 1909, 398, of 790,541 tons (including 63 vessels of 160,760 tons launched abroad), were built under the society's inspection with a view to classification in Lloyd's Register.

It is to be noted, however, that Lloyd's tables retain vessels as under construction so long as they remain in builders' hands, but they do not include unclassed vessels under 100 tons each.

As to the volume of the work produced, it is worthy of note that, in spite of keen competition, the Clyde remains the only compact British district that takes a place above any other country. It produced a great deal more tonnage than either the United States or Germany, more than double that of the Tyne or of any foreign country except the two already referred to, and only some 40,500 tons short of the output of the whole Northeast Coast of England. In the making of marine engines of the most powerful type the Clyde also takes first place, with a total of 200,000 indicated horse-power higher than the next best figures, viz., those of Germany. The following were the leading districts:

	Vessels	Tons	I. H. P.
The Clyde	354	403,187	610,985
United States	201	281,271	213,770
Germany	289	277,155	411,647
The Tyne	112	199,307	262,996
Holland	413	174,920	72,901
France	40	132,877	186,860

(We take these figures and many of those which follow from the annual statistics of "The Glasgow Herald.")

The Liverpool Underwriters' Association report that the number and gross tonnage of vessels lost during December were as follows: British, 4 sail, of 7,338 tons, and 7 steam, of 24,044 tons; foreign, 6 sail, of 7,278 tons, and 14 steam, of 23,871 tons—a grand total of 31 vessels of 62,531 tons, as compared with 17 vessels of 35,104 tons in December, 1908, and 24 of 39,631 tons in December, 1907. The following table shows the number and tonnage of vessels lost during each of the past three years:

BRITISH

	1909 Number	1909 Tons
Sail	19	30,460
Steam	60	174,967
Totals	79	205,427

	1908 Number	1908 Tons
Sail	22	33,663
Steam	74	185,609
Totals	96	219,272

	1907 Number	1907 Tons
Sail	20	33,386
Steam	61	150,960
Totals	81	184,346

OTHER COUNTRIES

	1909 Number	1909 Tons
Sail	56	76,787
Steam	105	195,734
Totals	161	272,521
Grand totals	240	477,948

	1908 Number	1908 Tons
Sail	72	89,319
Steam	107	200,922
Totals	179	290,241
Grand totals	275	509,513

	1907 Number	1907 Tons
Sail	82	94,145
Steam	105	219,721
Totals	187	313,866
Grand totals	268	498,212

Of the British ships lost during the year, 19 sailing vessels were total losses, 140 partial losses, 60 steamers total losses, 2,378 partial losses; and of the foreign vessels, 56 sailers were total losses, 298 partial losses, 105 steamers total losses and 2,635 partial losses—a total of 240 total losses and 5,451 partial losses, and a grand total of 5,691 losses, as compared with 5,949 in 1908, 6,131 in 1907, and 5,557 in 1906.

This leaves a wide margin for production, but Lloyd's figures do not include the tonnage broken up as obsolete.

The returns from the English shipbuilding districts show a condition very different from that at the end of 1908. There has not been anything like the revival in trade that is necessary to bring the industry back to normal, but there has been a gratifying recovery from the depression

which ran throughout 1908. There is a further decrease of tonnage on the Tyne—from 336,000 in 1907, 210,000 in 1908, and now to 199,000—but the Wear has advanced from 85,000 to 132,000, the Tees and Hartlepool from 96,000 to 122,000, the Mersey from 39,000 to 85,000, and the Humber from 21,000 to 24,000. There is a slight decrease in the English Channel district, making its output practically the same as that of 1907. The net increase is 19 vessels, 115,500 tons, and 194,200 indicated horse-power. The improving condition on the Wear and Tees is gratifying, as these districts were hit more badly by the depression than any others. They depend almost entirely on the building of cargo steamers. The advance of nearly 200,000 indicated horse-power marine engines constructed in the United Kingdom may be traced to the Tyne, Barrow and Birkenhead. The increase of 84,000 on the Tyne will be found in the destroyers built by Palmer's Company, the cruiser turbines by the Wallsend Slipway Company, the warship work done by the Parsons Company, and the increased number of steamers built at their own yard which Messrs. Swan, Hunter & Wigham Richardson have engined. At Barrow and Birkenhead warship machinery is also the great feature of the engineering returns.

The following shows the line, with output:

	1909		
	Vessels	Tons	I. H. P.
The Tyne	112	199,307	262,996
The Wear	57	132,633	95,556
Tees and Hartlepool	46	122,733	69,025
Mersey to Solway	92	85,228	164,950
Royal Dockyards	6	46,612	......
The Humber	72	24,414	35,375
English Channel	104	9,920	68,101
The Thames	96	7,053	11,618
Bristol Channel	57	5,399	762
Totals	642	633,299	708,382

	1908		
	Vessels	Tons	I. H. P.
The Tyne	115	210,110	178
The Wear	40	85,851	82
Tees and Hartlepool	38	98,061	60
Mersey and Solway	95	39,232	68
Royal Dockyards	5	43,060	..
The Humber	98	21,714	27
English Channel	106	10,237	66
The Thames	112	9,881	23
Bristol Channel	14	2,106	..
Totals	623	517,752	514

In spite of hopes of improving trade would tell on tonnage statistics all over the country, the Tyne failed to improve on its output for 1908, and the tonnage for that year was a good deal less than that of 1907. Messrs. Swan, Hunter & Wigham Richardson once more lead the district with an output of 71,000 tons gross—somewhat less than their total for 1908, but sufficient to give them second place for the world in the year. In the tonnage of the district there are a cruiser, two scouts and six torpedo-boat destroyers, while there is now a large amount of naval work on hand. In engineering, the Wallsend Slipway Company lead, with 55,800 indicated horse-power, included in which are turbines for a cruiser built by the Armstrong Company at Elswick. The Parsons Company constructed only warship turbines durng the year, for the Brazilian scouts built at Elswick and the Battleship *St. Vincent,* built at Portsmouth.

On the Wear the majority of the builders did a good deal better last year than in 1908, though there seems to be a falling off in the demand for turret steamers. Messrs. Doxford launched the self-discharging collier *Emma Sauber,* which is equipped with belt-discharging appliances to deliver coal into barges. An interesting vessel is the *Monotoria,* built by Messrs. Osbourne, Graham & Co. on a new principle of longitudinally grooved sides, which enable the vessel to steam at a given speed with less horse-power than would otherwise have been required. The Wear tonnage for the year showed a marked improvement over that of 1908, which, however, was less than a third of the year before. The prospects are improving to such an extent that Messrs. Laing's yard is being reopened. Quite a number of orders were booked in the autumn and winter, and most of the yards are now busy.

The anticipations of a revival which was held on the Clyde at the

beginning of 1909 have not been quite realized, but there has been enough actual improvement to show that these anticipations were based on knowledge of trade and on shrewd forecasting of the future. Most of the vessels then on the stocks have been launched, and many other orders have passed into actual work; a new situation has been created. The position is now very encouraging—more than it was at this time last year. The new year opened in circumstances to justify the belief that the amount of tonnage in the yards will continue to increase this year.

The warship building just now is immensely interesting. The Clyde obtained only one of the "contingent" battleships, but it received a large share of the work which the Admiralty allocated during last year. A battleship went to Beardmores, who are completing the second class cruiser *Gloucester* and laying down an improved sister-ship. At Clydebank Messrs. John Brown & Co. launched three of six destroyers, and have other three, as well as the cruiser *Bristol,* on hand. At Fairfield the cruiser *Glasgow* is completing, one destroyer has been launched, and there are five to come for the home Government and two for the Commonwealth of Australia. The London & Glasgow Shipbuilding Company have on hand the destroyer *Rattlesnake* and an improved Bristol cruiser. The engines for the former have been made by Messrs. Yarrow & Co., and those for the latter will be made by Messrs. John Brown & Co. A destroyer was placed with Messrs. A. & J. Inglis & Co. Messrs. Yarrow & Co. have two of ten Brazilian destroyers and some other light craft on hand. At Dumbarton Messrs. Denny & Bros. have the large destroyer *Maori,* and have other three still to complete, as well as one for Australia. At Greenock Scotts' Company are making progress with the battleship *Colossus,* placed with them last summer.

At the beginning of this year there were not many merchant vessels of importance building on the Clyde. The Fairfield Company had only destroyers on the stocks; the London & Glasgow Company had no mercantile work; at Pointhouse Messrs. Inglis had a MacBrayne line steamer, an Italian railway steamer, and a passenger steamer for Australia. Messrs. D. & W. Henderson & Co. had three vessels, each of 7,000 tons; Messrs. Mackie & Thomson two trawlers and one Booth Line steamer; Messrs. Alexander Stephen & Sons, three steamers of 19,000 tons aggregate; Messrs. Barclay, Curle & Co., three; Messrs. Charles Connell & Co., a Donaldson liner and one other vessel, and Messrs. John Brown & Co., Harwich and Hook of Holland boat and a large steam yacht. At Renfrew Messrs. Lobnitz & Co. had a rock-cutter, a large hopper barge, a stern-wheeler, a gold-dredger, and a small barge, and Messrs. Wm. Simons & Co. two dredgers. Messrs. Napier & Miller, Old Kilpatrick, had four steamers of about 11,600 tons. At Dumbarton Messrs. Denny had on hand a steamer for the New Zealand Shipping Company and a large vessel for Messrs. P. Henderson & Co., and Messrs. McMillan & Son had two on the stocks and two to lay down, making altogether for the town a total of about 34,000 tons. Greenock and Port-Glasgow had orders representing over 100,000 tons, but the work was not well distributed, as, while several of the shipbuilding firms have well-occupied berths, others are but sparsely served. Until a recent order for a P. & O. steamer, Messrs. Caird & Co.'s three yards were empty. H. M. S. *Colossus* was all the work in progress in the yard of Scotts' Company. The busiest firms within the radius are Messrs. Russell & Co. and Messrs. William Hamilton & Co., more than half of the above estimated tonnage being in these two yards, and in both cases the vessels are cargo steamers for service in various parts of the world.

Quite a number building by the latter firms are on the Isherwood system. Altogether the work on hand on the Clyde amounted at the beginning of the year to about 250,000 tons of merchant shipping and 73,000 tons of warships, a total of 323,000 tons, as compared with a little over 300,000 at the end of last year. But since January 1, a good many new orders have been booked, and many are still coming in.

A feature of recent development of the destroyer is that while Britain inclines to heavier vessels of large displacement and moderate speed, other Naval Powers are building light vessels of comparatively small displacement and high speed. Britain thinks more of sea-going qualities and radius of action than others do. In rough seawork 27-knot destroyers have proved faster than the lighter 30-knot vessels. We now have displacements of 1,100 tons, while the biggest German craft are no more than 700 tons displacement, with speeds of over 30 knots. The same tendency to weight is not seen in the Australian destroyers now on the stocks, but weight is the safe side on which to err, if it is not deterrent to speed. In the matter of propelling machinery the destroyer is in a transition stage. There are destroyers building with different kinds of turbines, and some with reciprocating engines. A British destroyer is to be propelled by Curtis turbines. In Germany the Parsons, the Curtis, the Melms and Pfenninger, and the Zoelly are to be found in vessels of the type; and there are French vessels with the Parsons, the Rateau, the Schneider-Zoelly, the Briquet, and a combination system. In one case Parsons turbines drive wing shafts, and a triple-expansion engine is on a centre shaft for cruising speeds. The submarine, again, is developing in size, radius of action and safety. British vessels now can go about anywhere and make quite long voyages on the coast.

A recent development is in commercial motor vessels—especially in the marine-motor fishing fleets. The total number of auxiliary powered drifters pursuing the industry in the North Sea a year ago amounted to a dozen, while now there are over 50 craft of this type, all fitted with heavy-oil, internal-combustion engines of 35 to 75 brake-horsepower. The majority of the engines are of the Gardner make, which was first in the field, but Kelvin, Beardmore, Thornycroft, Alpha, Fairbanks and Wear engines are also now in service. The steam drifter was introduced some six or seven years ago into Scottish waters in great numbers, practically putting the sailing lugger out of the market. At that time many owners of luggers sold them for a trifle or hauled them up, and, clubbing together, pursued the fishing with the modern steam drifter. Two years ago scores of good, serviceable luggers were upon the Scottish shore for good. With the introduction of the internal-combustion heavy-oil engine, however, conditions assumed a different aspect. It was soon seen that the old sailer, fitted with a 50 brake-horsepower installation, giving a calm-water speed of 7 knots, was much more profitable to run than a steam-propelled boat. In general commercial motor craft, last year also produced a number of barges, tugs, ferries, pilot-cutters, harbour service launches, lifeboats, etc., etc., all craft of under 70 feet in length, in which marine motor installations are fitted. Boats have been built for use in all climates and under all conditions, and whether for African rivers or water-carrying barges for harbour use, or high-speed pinnaces, the internal-combustion engine is taking the place of the reciprocating machinery.

There were, it may be remarked, no important developments during 1909 in the application of the steam turbine to marine propulsion, which certainly is capable of improvement, and the past year was a period of marking time, showing that the en-

gineering world is not sure what the next development is to be—whether the recipro-turbine combination is to prove still further its economy and efficiency, or whether it and the systems more generally used are to be superseded by a turbo-electric or other form of propulsion. It is now more than a dozen years since the problem of ship propulsion by steam turbines was solved, and by the efforts of the Hon. Charles A. Parsons the turbine was given a place along with the reciprocating engine as a prime mover for marine purposes. The progress made during that period has been very great, but we have now reached a time when we may assume that the immediate future will hold either further progress along the lines of the past or some radical development that will open a new chapter in turbine engineering.

The first Atlantic liner to be propelled by steam turbines was the Allan Line steamer *Victorian*, built and engined by Messrs. Workman, Clark & Co., Belfast, and launched in August, 1904. This vessel was soon followed by the Allan liner *Virginian* and by the Cunard liner *Carmania*. In 1903, the Cunard Company entered into an agreement with the British Government to build two large, high-speed steamships. The directors appointed a commission to report on the best means of propelling these vessels. Mr. James Bain, the marine superintendent of the Cunard Company, was chairman of this commission, which, after prolonged consideration, reported in favour of turbines. The Cunard Company, adopting the commission's recommendation, placed orders for two quadruple-screw turbine-propelled steamships of 760 feet length and about 70,000 horse-power—one, the *Lusitania*—to be built and engined by Messrs. John Brown & Co., Ltd., on the Clyde; and the *Mauretania*, to be built on the Tyne by Messrs. Swan, Hunter & Wigham Richardson, Ltd., and engined by the Wallsend Slipway & Engineering Company, Ltd. About the time when work was commenced on the construction of the *Lusitania* and *Mauretania*, the Admiralty decided on turbines for the propulsion of the new battleship *Dreadnought* and the new cruisers of the *Invincible* class, so that within nine years of the success of the *Turbinia* the turbine was adopted for the largest war and merchant ships in the world.

Ever since the success of the *Turbinia* there has been much controversy as to the relative merits of reciprocating and turbine-propelled ships. The extent to which the turbine will be employed in the future remains an open question, but recent developments give some idea of what may be expected. The divergence of views among engineers and shipping men is less pronounced now than formerly. The turbine is generally admitted to be preferable for warships, and not suitable, used alone, for propelling slow-speed cargo vessels. Much interest is now taken in propelling vessels by a combination of reciprocating engines and turbines. In this recipro-turbine combination the steam is first used to drive two sets of ordinary reciprocating marine engines, and is then passed on to a centrally-disposed turbine. This arrangement is an old idea of Mr. Parsons', and is based on the advantage of the turbine over the reciprocating engine in point of economy, wherein lies its practical ability to expand the steam to a large volume and at low pressure. In the recipro-turbine combination, reciprocating engines may be employed for that portion of the expansion in which they can extract from the steam as much useful work as a turbine; and a turbine is then employed to complete the work-extracting. Comparing the recipro-turbine combination with the ordinary reciprocating drive for a cargo steamer in the former, the engines and shafting require more space than in the latter. But owing to its

greater steam economy, less boiler power is required with the recipro-turbine combination, and a saving in weight in this respect is effected. The better economy also reduces the bunker weights, so that the recipro-turbine combination has its greatest advantages for vessels going long voyages without recoaling, while a high vacuum is as necessary with the recipro-turbine combination as in the case of a vessel propelled by turbines only; the conditions in the former are much more favourable for air leakage than in the latter, so that the maintaining of a given vacuum will be a more difficult matter.

There has been much discussion as to the relative merits of propulsion by Parsons turbines driving three or four shafts and impulse turbines arranged on two shafts only. In the usual arrangement of Parsons turbines either three or four main-ahead turbines are employed, two of these being low-pressure machines and one or two high pressure. Each turbine drives a propeller shaft, so that there are either three or four shafts. In the four-shaft arrangement the turbines consist of two independent units, each comprising a high-pressure and a low-pressure turbine. These units are run independently of each other. In the three-shaft arrangement both low-pressure turbines receive steam from a common high-pressure machine, and there are not two distinct units; but either low-pressure turbine can be taken out if desired and the other two turbines continue working. In the usual arrangement there are only two main-ahead turbines. Each of these undertakes the complete expansion of the steam and is quite independent of the other. Each drives a shaft. In both arrangements only prolonged experience can determine which is the better.

The two systems are fitted on the United States scout cruisers *Chester* and *Salem,* the former having four-shaft Parsons and the latter two-shaft Curtis turbines. These cruisers are the first United States warships to be turbine-propelled, and may not contain such good machinery designs as could be adopted later. In both vessels there are two engine-rooms separated by a cross bulkhead, a high and a low-pressure turbine and a condenser being in each room in the case of the *Chester,* and a complete turbine and a condenser in each room in the case of the *Salem,* so that the disabling of the whole propelling machinery by a single projectile is unlikely in the two ships.

As to the number of naval ships to be laid down, the programme of 1910 has been bequeathed to Sir Arthur Wilson. The number of ships must necessarily depend upon their characteristics. If important changes are necessary in the design of ships, the rate of construction may be altered to reap a greater advantage. In Germany the changes involved by the construction of the *Dreadnought* imposed a suspense of nearly a year. The Cawdor programme of 1905 proposed the beginning of four big armoured ships per annum. It was reduced in the following year. The latest ships will be more powerful than if they had been laid down at the rate of four per annum from 1906. Taking into account the four "contingent" ships of 1909, the same number of ships will have been begun within the four years as the Cawdor programme contemplated, viz., sixteen. Sir John Fisher favoured six capital ships each year. His programme for 1910-11 included the commencement of four "capital" ships, super-Dreadnoughts or Invincibles. This number is made possible by the fact that, including the four "contingent" ships, eight were in the programme of 1909-10. Thus twelve will be put in hand within two years. The present rate of shipbuilding is based largely upon that of Germany, and the German Government, which from 1908 to 1911 includes four big ships per annum.

Of destroyers the programme of 1909-10 includes twenty, which number will suffice to maintain and increase the British lead. Germany is

building twelve per annum, the complete programme including 144. British builders can turn out a destroyer ready for sea within twelve months. The Germans allow two years.

In the matter of turbines a question much discussed of late is the turbo-electric system of propulsion. There is a "best speed" of rotation for the screw propeller, at which speed maximum propeller efficiency is obtained. As the speed of rotation is increased above this "best speed" the efficiency falls off. In order to get reasonable propeller efficiency with turbine-propelled steamships the turbines have to be run at considerably lower speeds than are adopted in the driving of electric generators. High-speed turbines are lighter and cheaper than low-speed machines of the same type for a given maximum effective horse-power, and can be built to give a greater overall efficiency. To obtain high propeller efficiency combined with high-speed turbines, it is proposed to transmit the whole or part of the power electrically from the turbine to the propeller shaft. One or more high-speed turbines could be employed direct-coupled to electric generators, which would supply current to electric motors on the propeller shaft or shafts. The propellers could rotate at a low speed, and the turbine would be small, light and economical. The advantages of such an arrangement have been discussed, and a tender for a United States battleship involved a drive of this nature. As an alternative to electric transmission of power, gearing has been proposed, the total engine power or part of it being transmitted by chain or spur gearing from a high-speed turbine to a low-speed propeller shaft. The objections to gearing have probably been overrated, but it is not, for large vessels, impossible.

The use of superheated steam in turbine steamships is also being considered. Steam turbines on land are commonly supplied with superheated steam, but no turbine-propelled ships built in Great Britain have yet been provided with superheaters. The abrupt admission of high temperature steam to a turbine without previously heating up the machine is attended with risk of injury to the engine. Saturated steam at a pressure of 180 pounds per square inch has a temperature of 380 degrees Fahrenheit, and the sudden admission of steam at this temperature to a cold turbine is bad. If the steam is superheated to 150 degrees, the case is worse. Reversing on board ship has often to be accomplished suddenly and without warning. It is not surprising that superheating is regarded with disfavour from the turbine point of view. Many engineers advocate astern turbines constantly heated up by intermittently passing blasts of steam through them. Mr. Parsons has a patent for the employment of a heat "buffer" between the turbine and the boiler to shield the former from abrupt changes of temperature, and to reduce the risks involved in the employment of superheated steam in turbine steamships. The employment of superheaters on steamships is now looked on with less disfavour than formerly.

The idea of jet propulsion has been revived, and the functions now obtained by centrifugal pumps directly coupled to steam turbines, with lightness, simplicity and moderate cost of the machines, suggest factors of considerable inportance in favour of the advantages of jet propulsion. Improvements, moreover, have been made both in the pumps and in the method of discharging the jets. Failure which resulted before these improvements were effected need not now be anticipated, and does not prevent success in the future under more favourable conditions. The German Society of Naval Architects recently discussed the subject, and experiments will be welcomed. Steam turbine propulsion is in an unsettled state at present. Much difference of opinion exists as to the relative economy of turbine and recipro-propelled vessels and there is no doubt about the various schemes for increasing the economy.

There is still a chance that a type of screw-propeller may be found which will work efficiently at high speeds of rotation. The Vulcan Company, of Stettin, have produced hydraulic reduction and reversing gear whereby to run a marine steam turbine at a high, and the propeller shaft at a low, speed of rotation. The transmission gear, whether for ahead or for astern running, comprises a primary water turbine mounted on the steam turbine shaft, and a secondary water turbine mounted on the propeller shaft. The primary water turbine converts the steam turbine shaft power into hydraulic power, which latter is reconverted into shaft power by the secondary water turbine. An efficiency of transmission of over 80 per cent. is said to have been obtained by this gear.

The severity of the depression in building in 1908 and 1909, which proportionately was very much greater than in any previous period of depression during the last twenty-five years, must have a reacting tendency, and signs are not wanting that the building in 1910, while not exceptional, will be considerably in excess of the low figures of the last two years. At the present time builders have quite a number of orders on their books for merchant tonnage to be delivered during the year 1910.

It is the output for 1909 which will have the greatest effect on freights during the earlier part of 1910, and an additional tonnage of 750,000 tons would require an additional annual trade of about 5,000,000 tons to keep it in employment throughout the year.

At the present time there is a certain amount of tonnage laid up, but these vessels are mostly of the older type, which, under severe competition, are unable to be run at a profit. Any improvement in freights would bring these vessels into the market to compete with the present employed tonnage. It will be seen that with the existing tonnage in employment, the laid-up tonnage and the new tonnage being built, an addition of something over 5,000,000 tons of cargo will be required in 1910 over that carried in 1909, to keep freights even as good as they have recently been. If the cargo required to be shipped across the seas is much in excess of this figure, it can only result in an increase in freights. If on the other hand the cargo requirements are considerably below this figure, the demand for tonnage must continue below the supply, and the freight market still remain in a low condition.

The world's mercantile marine during the past twelve years has been increased by 18,000,000 tons added to the tonnage on the seas. The greatest addition was in the year 1906, when, after allowing for wastages, more than 2,000,000 tons were added. In 1906 and 1907 the supply and demand for tonnage reached a point at which the one pretty well balanced the other, but in 1907 the expansion in trade reached its highest point, and at the end of that year a crisis occurred in the United States. The builders of shipping had orders on their books, and they put on the water a considerable amount of tonnage in excess of what is annually lost. The depression in shipping, which commenced in 1907, continued throughout 1908 and the early part of 1909. In February, 1909, it was estimated that the number of vessels laid up at ports in the United Kingdom and on the continent amounted to 1,065, with a total tonnage of 1,500,000 tons. Since then there has been some improvement in shipping, and enough to attract a considerable portion of this tonnage back to ordinary trading. At the end of December, 1908, there were 112 vessels laid up in the Tyne, and by August, 1909, this number had been reduced to 53.

At a recent meeting of the Scottish staff of Lloyd's Register of British and Foreign Shipping, Mr. F. G. Gardiner, shipowner (chairman of the Glasgow Committee of Lloyd's Register), said he could not find in Lloyd's any indications of senile decay. He thought it was very much alive. There

was something like 21,000,000 tons of shipping on its register, and no less than 7,000,000 of foreign tonnage. Between 1900 and 1909 they classed over 12,000,000 tons of shipping. Last year, out of the whole of the tonnage built in British for British classification, no less than 84 per cent. was classed with Lloyd's. At the present time some 920,000 tons are building in Great Britain to be classed by Lloyd's and 300,000 tons abroad. The British tonnage was 40 per cent. more than for the whole of last year.

Mr. J. H. Heck, of Lloyd's, says that British ships and shipping have done much to build up the great British Empire and to foster the British characteristics of probity and self-reliance. We are indebted to merchants and seamen for much of our food. The welfare, even the existence, of the country is bound up in its shipping interests. Many years ago Sir Walter Raleigh said that whosoever commanded the sea commanded the trade, whosoever commanded the trade of the world commanded the riches of the world, and therefore the world itself. Some years ago, when the Committee of Lloyd's Register was first formed, shipping was in a bad way. The average daily loss was high. We had not only lost much of the carrying trade of the foreign merchant, but even the British merchant found it to his advantage as an individual to employ a much greater proportion of foreign ships. British shipbuilders were behind the times, each had his own ideas about scantlings and strength, there was very little real supervision in construction, and our ships were so slow that foreign vessels could make their voyages in about a third less time. Contrast these conditions with the present day. All classed vessels are now built under survey, and under rules which are the outcome of technical knowledge and experience. Every time such vessels are dry-docked in any part of the world they are examined by a Lloyd's surveyor, who reports on their condition. The information thus supplied by trained technical men enables the rules of the society to be adjusted from time to time in the direction either of reduction or increase of local strength. Shipping interests, however, can only flourish when they have a strong navy to look after them. Confidence depends on it, and confidence is the first law of commerce. Strength, whether in a navy or in the character of a vessel, always pays best. A good ship makes good voyages, burns less coal and costs least for repairs, while a poor ship makes a poor return for the outlay incurred.

Mr. Lawrence Glen, shipowner, said that one of the marvels of the age is the extreme cheapness of ocean carriage. The modern tramp steamer could carry her cargo 1,000 miles for 9d. per ton and make a profit of 10 per cent. The only drawback is that the shipowners never got the 9d., and they are therefore to do without the 10 per cent. A modern tramp steamer could leave England and go round the world by the two Capes, and even then carry cargo at £2 8*s*. per ton. These are marvelous figures, and they show to what extent the world is indebted to the carrying trade. A great deal of credit is due to the shipbuilders and steelmakers for producing ships that can be run at these rates. Many owners besides Mr. Glen think it a pity to see so much "top hamper" as there is now on many liners. There is also far too much luxury connected with liners. It is not necessary for shipowners to model their arrangements on the style of London West End hotels. There is something of the same tendency towards top hamper among tramp steamers, and some of them are not much more than glorified lighters with forests of derricks. There is too much discharging and loading machinery on the deck of a ship. The proper place for such things is on shore. To some people a ship is only something that would carry a certain amount of cargo, and it is a pity that the British tramp ship should be manned by the dregs of humanity. Something might be done

to raise the status of the British sailor.

Progress in marine engineering in the production of power with economy is due to increase of steam pressure, increase in the number of cylinders and increase in the number of cranks. The rise in steam pressure makes possible a greater expansion of the steam, and more of the heat it contains is utilized for the production of work. The increase in the number of cylinders has enabled the greater expansion of the steam to be carried out under conditions favourable for economy. The increase in the number of cranks has produced more uniform rotation of the shafting and greater freedom from vibration and racing. Of triple-expansion engines experience soon showed that vessels fitted with engines having three cylinders and two cranks were not so economical as vessels fitted with engines having three cylinders and three cranks. Vessels fitted with two-crank compound engines working with high pressures of steam were found not so economical or efficient as similar vessels fitted with triple-expansion engines having three cylinders and three cranks and working with the same high pressure of steam. In vessels fitted with engines having four or more cylinders and a crank for each cylinder it was found that they are more economical when compared with engines having a smaller number of cylinders and cranks. Some engineers with experience of multi-crank engines claim that such engines burn less coal, make more uniform passages and cost less for repair and upkeep.

Development in size and speed of vessels and in pressures of steam has led to economy in weight and to an increase of piston speed and speed of revolution, in order to produce greater power from an engine of given size. Increase of revolution produces in proportion a greater increase in the inertia forces, and had to be met by extra weight and an increase in the number of cranks. Therefore four-crank engines (and engines with a greater number of cranks) have been brought into use. These engines are more free from racing and vibration, as with a greater number of cranks the resultant action of the forces producing vibration can be reduced by a balance among themselves, to diminish the effects of each other.

Lloyd's Register gives particulars of 500 vessels fitted with quadruple and four-crank engines. The tonnage of the vessels so fitted amounts to 3,230,000 tons gross and the engine power to 320,700 I. H. P.

How long will it be before we find a record as large of merchant vessels with internal-combustion engines and burning oil fuel?

THE DEVELOPMENT OF INVENTIONS

By Arthur Pestel

WHEN a new invention has been established, its development brings forward many difficulties. It, therefore, may be of interest to consider this subject systematically and study its different methods, so that a clearer view of the advantages, as well as disadvantages, of different plans may be obtained.

There are three methods available in commencing the development of an invention. The adoption of either depends mainly on the nature of the device and also on the experience and technical training of the inventor.

First.—A rough model may be made of either wood or any other suitable material, so that the practicability of the invention may be demonstrated.

Second.—If certain features only are doubtful in regard to their practicability, each one ought to be developed separately, and, when satisfactory, combined with the others in the design of the whole.

Third.—If practical demonstrations as above mentioned are not essential, a design with all calculations and drawings may first be made and the invention completed according to these plans.

The first method is usually applied in cases in which the invention consists of single movements and mechanism, and where the manufacture of a single machine involves a heavy cost, as in the case of large machines required in connection with excavating, building and mining work, and the like.

In the development of inventions of such character a scientific training of the originator is not so essential as the inventive ability and practical training in applied mechanics. The model, generally of reduced size, is made only to prove that the principle is right, and if any members or parts should be out of proportion in regard to size or strength of material, it will not matter as long as the invention has shown its vitality by means of the model, which can be corrected and rightly calculated and drawn into a full-sized machine later by the designing engineer.

The second method implies inventions with complicated motions and devices, such as automatic machines for replacement of hand labour, agricultural machines, tools and screw machines, printing and type-setting machines. Also, complicated instruments must be placed in this class.

When all the movements have been analyzed and sketched out, it is generally found advisable to separate the most difficult features and develop and test them independently of the others.

After they have been made and found to be satisfactory, it will then be necessary to calculate and combine all features in a design which comprises the whole of the invention. In such cases the originator should have a thoroughly analytic mind, and a good, practical and a more or less theoretical training is a necessity, even if for the final design he should employ an efficient engineer.

The third method deals with inventions for which all the calculations and drawings are made first, and for which the principal require-

ment is the behaviour of such agents as steam, electricity, gasoline, etc., rather than the demonstration of the practicability of complicated mechanism.

In this group prime movers and similar machines may be classed, being mostly inventions of a highly scientific character, which, therefore, require a more or less academic training on the part of the originator.

When the principle of an invention has been established as being sound and its different features considered to be satisfactory, it is necessary to obtain assistance for the various portions of the work.

The engineer, draftsman, mechanic and labourer are, therefore, the men who have to be taken into consideration. The inventor himself may be in the favourable position to replace the first and possibly the second of the above mentioned. This, however, we shall not consider, and the question of an engineer arises.

The requirements for such a man depend on the nature of the invention, and must be decided by the originator. If it is a machine in which strength of material, or physical properties of materials, or of gases, liquids, etc., have to be taken into consideration, or especially when mathematical investigations are required, the necessity for an engineer becomes absolute.

Many of them, however, lack real practical experience for this kind of work, and the inventor finds at this point obstacles placed before him which at least may prolong the process of development.

The inventor who, in some instances, would adapt simple devices which he, perhaps, has seen somewhere in practical operation, is possibly forced to replace them by more complicated artifices, because for different reasons the engineer cannot always adapt the former. He is not allowed to make certain contrivances, as imagined by the inventor. His technical training will not permit him to accept any poor or chance idea. He has to deal with cold facts, and cannot let his imagination go astray, especially when he has to take responsibility in regard to dangerous developments.

If the invention is of such a nature that, in the beginning, no engineer is required (first and second method), the originator, in dealing with the draughtsman and mechanic, or with the latter only, will find that he has to choose one out of two methods, either:

(A) His assistants make each part and device according to his directions only, and are in no way left at liberty in developing the invention.

(B) His assistants participate directly in the development of the invention, and are allowed to make suggestions in regard to improvements in parts or devices, and also are given a certain liberty in their formation and production.

Method A characterizes itself as being the most scientific. All directions are given from one source, passing from the engineer to the draughtsmen, mechanics and labourers.

A drawing is given of each detail, and whenever a change is to be made, corrected drawings are furnished to the mechanics. In this way the originator never sees, or at least need not see, his help personally, they being only a part of a system.

Method B is not so strict in regard to the application of purely scientific methods, and lends rather itself more toward individualism. It accepts science only in so far as it seems to help in technical developments and utilizes all available aid of the assistants, especially in regard to changes and improvements in the invention.

With the selection of either one of these two methods the inventor is confronted. The conditions, which are always different in each case, must be met by him, and it depends on his originality to know which method to choose.

His own nature, ability and character, as well as those of his help, are factors to be considered in the selection of either of them.

Both methods have their advantages and disadvantages, and with either good results are attainable.

While studying them more closely, it will be found that in choosing Method A the inventor has the advantage of regarding all patentable claims as his own, thus being free in his actions and without any obligations to others. Fear in regard to claims which others may make upon an invention is a continual source of trouble to an originator. On this account Method A is often adopted, when, for other reasons, Method B might be found preferable. This latter method presents especially the advantage that, for all details, alterations and improvements, a record is given by means of the drawings which may prove to be valuable for future reference in regard to duplicate work, claims on patent, etc., if date is properly given.

In Method A it is not necessary to have as much intelligence on the part of the workman as in Method B. When a complete drawing is made of each part it requires less training on the part of the mechanic than if the piece is to be made without such full instructions, relying upon his individual ability. More time is required for Method A, however, since a mechanic can often complete a job before the detail drawing could be made, especially if changes and improvements are considered.

When drawings are given, the workman is seldom aware of the principle of the invention or even of the improvement being made, and, not knowing what the parts are meant for, has to make each one more carefully in order to comply with the drawings. He often wastes time on parts in which dimensions might possibly differ to a slight degree, thus expending more time and care than necessary.

This disadvantage is somewhat reduced by the adoption of Method B. Instead of giving a drawing of each part, a rough sketch, or even verbal directions, will often suffice, thus leaving the development more or less to the mechanic, which in many cases will give more practical and also quicker results.

If difficulties arise, especially in regard to details, the mechanic, with his practical training, can often overcome them more easily, and thus may be able to take from the inventor the care for minor things, leaving his mind open for broader and wider subjects.

The originator being in close contact with his men, may also be able to learn practical points through observation and conversation. Nearly every good mechanic has different methods of his own for overcoming certain difficulties, and keeping in constant touch with these men has proven beneficial in many respects.

When adopting Method B the inventor may be able to arouse his men to more interest in their work and be able to awaken them to greater activity. It is remarkable what knowledge is sometimes to be found amongst these men. By rightly awakening their interest, thus bringing forth their latent powers, carefully directing and utilizing their efforts to the highest degree, one may be able to obtain the best and quickest results possible. Faculties which otherwise would have remained hidden and been lost are thus made productive.

This method can, however, as stated before, prove disadvantageous in so far that it may give the men claims on patent rights, which often causes difficulties, especially if the assistant places too much worth on the merit of a certain improvement of a part or even movement. It not seldom happens that the mind of an assistant, being entirely occupied with the development of certain movements, loses sight of the main principle which is being established by

the originator, and comes to the conclusion that it is only through his improvements that the invention has been made vital, thus claiming excessive advantages for himself. Such claims generally cannot be granted; the man, therefore, loses interest in his work or goes away to another concern, possibly a competitor, after having been educated in that special work, and may sell his training and ability to the disadvantage of the originator.

The attitude toward the inventor, in cases as above mentioned, is sometimes unbearable on account of the intense struggle of the assistant for recognition in connection with improvements, which in the latter's eyes—who usually sees only one side of the proposition—are ideal; and any criticism on the part of the originator is often considered to be caused by selfish motives.

These are the main disadvantages of Method B, and while it is not every good mechanic who loses his head on such occasions, yet experience shows that in many cases even the most stable mind has its weaknesses, especially in such fascinating subjects as establishing and realizing his own new ideas. The privilege of any claims on patent-rights may, of course, be held by the originator by making a contract with his assistants; but this does not give always the best results, on account of the loss of interest which then often follows, thus producing a slower result. Besides, the position which the inventor has to maintain in case of difficulties which are overcome by his helpers will remain the same.

If, however, he is in a position to deal with men who are free from such selfish desires, Method B seems to be the most advantageous, besides being more rational and democratic than the other, which bears somewhat the character of absolutism.

The ambition, zeal and effort of the men are mostly hampered and lost with Method A, on account of the automatic nature of the work, when for every detail and change specified directions, with a drawing, are given under the supervision of one man, the originator.

The men become mere slaves of this system and act more like machines, having no special interest whatsoever in the final outcome of the invention.

Method A, which is mostly adopted in large concerns and in nearly all European countries, is, from the scientific point of view, the best, while the other, with its more democratic character, develops the individuality of the assistants to a great degree on account of the inventor readily mingling with his men, hearing their opinions in regard to details and improvements, and thus creating more interest and ambition among them.

This method has proved to be of great advantage in the United States, and it is hardly possible that the development, especially in tools and all automatic machines replacing hand labour, would have shown such great steps forward if individuality had not been given its opportunity.

Much more, of course, is demanded of the originator, who, besides the knowledge of the subject of his invention, is also required to have a good understanding of men in general, in order to get the best results from them. Familiarity with their ways of thinking, their character, as well as their moral standing, is an absolute necessity, and the study of psychology seems to be very essential.

THE RELATION OF CANALS TO RAILWAY TRANSPORT

THE PRESENT SITUATION IN ENGLAND

By S. Whettal

In all parts of the world the question of the economical transport of merchandise has become of controlling importance. Waterways, formerly the principal means for the transportation of all kinds of materials, have been largely superseded by railways, but with the increasing cost of railway transport, statesmen in the United States, in Germany, and in Great Britain, have become aroused to the importance of providing the competition which can alone be afforded by an independent system of canals, equipped with modern appliances, and handled according to modern business methods. Mr. Whettal discusses the present situation so far as Great Britain is concerned, and his arguments may well be extended to include the subject in other parts of the world.—The Editor.

THE question of transport is of importance to all readers, and the problem is made more interesting at the moment owing to some remarks which have recently been made by the chairman of one of the leading railway companies. Seeing that the remarks were in respect to the charge made for transport over the railway, they may be quoted here. The remarks made by this influential gentleman were as follows: "An important decision had been given by the Railway Commissioners in what was called the coal case. In July, 1907, when the railways were not only paying high prices for coal, but also for other materials, the increased cost of working the traffic was pressing upon the railways, and the companies decided to make an additional charge of 2½ per cent. for the carriage of a certain class of coal. The coal merchants declined to pay the extra charge, and action was taken by some of the railway companies to recover the charge. Thereupon the coal merchants and others interested in the trade laid the case before the Railway Commissioners, who, after hearing both sides, decided that the increased charge was reasonable and was justfied by the increased cost of working. Apart altogether from the money involved in this particular advance, the decision of the Commissioners was important in that it recognized the principle that the increased burden put upon the railway companies was a justificaton for increasing their charges."

From the above statement it is easy to understand what attitude the railway companies will take with respect to increasing many of the existing railway rates. It is, perhaps, as well to note that these remarks were passed at a time when the majority of railway shareholders were congratulating themselves upon increased dividends. It is also well to know that the railway companies do not control all the carrying businesses, seeing that it is from one of their competitors—the canals—that the traders may expect concessions in rates. Therefore, a few remarks on this question will probably be of interest to all traders connected with any business whose goods are non-perishable. The following statistics show the relative size of British canals, both independent and railway-owned, and railways, along with the tonnage and receipts:

STATISTICS OF BRITISH RAILWAYS AND CANALS

	Length in miles.	Paid-up capital in millions. £	Traffic in millions. Tons.	Net receipts in millions. £	Net receipts per mile. £
Railways	23,074	1,287.4	414.2	44.4	1,924
Canals not owned by Railway Companies	2,768	37.9	33.3	.6	216
Canals owned by Railway Companies	1,138	Not stated	6.0	.05	40

The reader will notice the great disparity between the amounts received for carriage from those canals owned by the railway companies and those owned by the canal companies. It is certainly instructive to learn that, on the one hand, the net amount per mile was £216; in the case of the railway-owned canals it was only £40 per mile. It is, therefore, apparent that the railway-owned canals are certainly not paying the railway companies, and this is borne out when one compares the neglected state of these canals in comparison to those owned by private enterprise; so that the only inference to be drawn is that the railway companies are evidently not desirous that their canals shall be too successful. This will, no doubt, be quite obvious, although the reader will probably agree that the railway companies are thus going against the true interest of the traders by allowing their waterways to be given over to the weeds and fishes. A trader who forwards non-perishable traffic is bound to be concerned in the cost of transport, and anything which is likely to cheapen the cost of such transport is desirable and necessary. One conclusion is easily arrived at, and that is: Were railways to work more in conjunction with the canal companies and develop their own canals to a greater extent, then they would, in all probability, be able to lower the existing railway rates instead of being desirous of increasing them.

Where canal competition exists, the trader generally receives the benefit of such competition, as the following information will show.

The figures given thereunder have been compiled from a reliable source, and they give the rates as based upon the maximum charges, as well as the actual rates in force, between the places Manchester and Liverpool, and Newcastle and Leeds, respectively. It may be mentioned that all maximum charges are common to the canals as well as to the railways, and that it is in respect to the special and exceptional rates which are in operation for all classes of goods, that the canal companies can give the trader the benefit of low rates. The maximum rates are fixed by law and the minimum rates are agreed upon at a conference between the various railway and canal companies, so that it is clear that the canal companies endeavour to keep the rates as low as possible, because this is the only chance the canal companies have of securing a fair share of the traffic. In the following are given the rates between Manchester and Liverpool, where competition exists between railways and canals, distance 34 miles:

Rates actually in operation.

Classes.	0	1	2	3
Per ton	7/	7/11	9/2	10/10

Rates based upon maximum charges.

Classes.	0	1	2	3
Per ton	7/5	9/11	11/10	13/8

Note.—No allowance made for cartage.

From the figures given above it will be noticed that the actual rate in operation is in every instance below the rate when based upon the maximum charges, and this clearly proves that the railway companies have been compelled, through canal competition, to lower their rates. As a comparison, take the figures given hereunder, which show the rates where there is no canal competition. The places are Newcastle and Leeds, distance 100 miles:

Rates actually in operation.

Classes.	0	1	2	3
Per ton	13/9	20/5	25/5	29/3

Rates based upon maximum charges.

Classes.	0	1	2	3
Per ton	14/5	20/11	25/4	29/4

Note.—An approximate allowance for cartage is included in the above maximum charges.

The particulars given herein will tend to prove that canals are beneficial to the trader, as they have the tendency to reduce the carrying rates, and it appears very possible that in the near future the trader will have still further assistance from the canals, as the Canal Commission has reported favourably on a scheme to improve and reconstruct the inland waterways. As it is possible to give only a brief outline of the scheme in these pages, but a few details can be mentioned in this short article. The main proposal is to form a central waterway board and vest in the members of the board the power of working the canals solely in the interests of the public. It is proposed to have four large trunks connecting the Midland area of Birmingham, Wolverhampton, Nottingham, etc., with the Thames, the Severn, the Mersey and the Humber. A service will be provided with boats of a minimum capacity of 100 tons in some districts and 300 tons in others, to suit the requirements of the canal or the needs of the district. The Commissioners estimate that the cost of reconstruction, etc., will be 17.5 million pounds, and to cover the cost of maintenance and other charges a gross revenue of just over 1 million pounds will be required. When traders get to know that cheaper rates can be obtained in districts where canals compete with the railways, they will doubtless be anxious for the canal systems to be improved. For commercial development to be fully extended, it is essential that both the railways and the canals be improved and worked as economically and as scientifically as practicable, so that a maximum amount of benefit is obtained at a minimum amount of expense. If this were done, the trader would reap the benefit; because when transport charges are so high, so, too, are the prices of both raw and finished materials, and whatever price is charged for carriage must be borne by the article as an additional charge.

There is plenty of room for improvement and addition to the British canal system, more particularly in the case in the northeastern part of England, where there are no canals for miles upon miles. It, therefore, transpires that the railway company there has a monopoly, which is not altogether beneficial to the public generally. As a result of this monopoly the railway company in this railway district insists that wagons which the trader requires to travel through to a destination from a siding, shall be charged at a minimum charge as for two tons. The result is that, when the trader has a load of about one-half ton, which his customer requires urgently and the traffic cannot wait for transshipment, the railway must have 300 per cent. extra, and in return the trader gets the privilege of being able to send the goods through to destination without being transshipped. The railway company takes no more liability for delay than is usual, and this is, of course, practically "nil." Where there is competition between the canals and the railways, and even between the railways themselves, it is possible to send urgent goods when under one ton, provided the traffic is paid for as a full ton, so that it proves cheaper for the trader when competition is keener.

With the railways owning one-third of the existing canals, they have been in the position to cramp the development of the canals to a great extent, and perhaps their policy will not turn out to be the best thing for themselves. Owing to the fact, that the waterways have been allowed to get into such a bad condition, they have deteriorated so much that it will be impossible for them to be used unless great expense is incurred.

Should the canals be reconstructed, they will secure a lot of traffic which is at the present time carried by the railway companies, especially that traffic which does not demand exceptionally speedy transport. The

cost of working the canals is much less than the cost of working the railways, so that, naturally, the canal companies can offer better inducements with respect to low rates than can the railway companies. The working cost of the railways at the present time will not allow of any reduction in the rates; in fact, according to a high railway authority on railway matters, the rates would in all probability be increased in the near future. An approximate estimate for the cost of the appliances to carry 250 tons of goods is that it would cost the railway companies five times more than the canals for their purchase.

Before the canals can hope to compete on favourable terms with the railways, they will have to improve the methods of haulage considerably and introduce the latest steam and motor barges. In America electric haulage has been tried on many of the larger canals, and, on the whole, it is fairly successful. Great Britain is rather behind with respect to canal transport, particularly so with regard to haulage and in connection with the construction of locks.

In conclusion, it may be said that the traders who forward such heavy traffic as machinery, boilers, raw materials, pig-iron, manufactured steel, coal and similar materials, will gladly welcome any innovation which is likely to reduce the carriage charges, as the percentage of the gross value of the goods paid in freight charges is, at the present time, about 5 per cent. on some materials, whilst on coal and other minerals it varies from 40 to 60 per cent. The reader will probably appreciate the necessity for an improvement in the methods of transport whereby lower rates can be obtained.

THE RAILWAYS OF BRAZIL

By Lionel Wiener

In considering the possibilities of the natural resources of Brazil, one of the most important elements lies in the transportation facilities, and hence the series of articles upon the railways of the country, of which the first is here given, will be found of especial value. When it is realized that the area of Brazil is somewhat greater than that of the United States, and but little less than the entire area of Europe, and that it already has a population of more than nineteen millions, it will be understood to how great a degree its future is bound up with the development of such railway systems as will enable it to be exploited, and with such development almost boundless wealth will be rendered accessible. Future articles by Mr. Wiener, whose opportunities on the spot render him especially well qualified to treat the subject, will include detailed accounts of the various lines.—The Editor.

BRAZIL is no exception to the general rule prevailing in South America, and a number of its railways are owned or worked by British companies. But lately several lines have been bought back by Government and American companies floated to work them.

This Pan-American movement is growing apace, and it is understood that American capitalists have been buying heavily, with the object of the formation of a combination of the larger railways, harbours and tramway systems.

Collecting accurate information about these railways is particularly difficult, not only because they are granted under such a variety of laws and either by the "Union" or by the "States," but also because such partial statistics as do exist are inaccurate and obsolete.

I propose giving, in the following pages, a sketch of Brazilian railways, their history and situation up to the present date.

As far back as 1835, and thirteen years only after the birth of the Empire, a bill was passed authorizing the government to concede railroads from Rio to the capitals of what were then the provinces of Minas Geraes, Bahia and Southern Rio Grande. It is noteworthy that Brazil was one of the first countries to follow England's lead in granting railway lines (though not in building them), England, Belgium and Brazil following in close succession (as with postage stamps); also, that these lines were granted at the very outset as part of a general plan for joining the capitals of the outlying provinces with the capital of the Empire. It is equally noteworthy that nothing came of it all, not for many, many years.

These lines had been granted for forty years only, and even in those remote days it was in England that the Marquis of Barbacena sought the funds for floating the company, but failed to do so, as the financial future of the company was too uncertain. It is curious to note that today, three-quarters of a century later, one of these lines only is in operation, neither the capitals of Bahia nor of Southern Rio Grande having railway communication with Rio de Janeiro.

On June 26 another law was passed authorizing the government to grant private companies during ninety years a guarantee of 5 per cent. interest on the estimated cost of the line, and the provinces another 2 per cent., countersigned by the government. The actual guaranteed capital was subject to readjustment after the building should be completed.

The concession was perpetual, but, after the first thirty years, the right of redemption might be exerted. The company was also granted a protected zone of five Brazilian

leagues on either side (the Brazilian league is 6,600 metres, or 7,218 yards), within which no other company would be allowed to build competing lines, besides a number of other advantages, such as the free use of timber or other material existing on unoccupied or national land, the exemption of duty on all construction material, whether for the line or the workshops, and on the coal for the locomotives.

On the other hand, the government fixed the maximum tariffs, as follows:

Export goods, 54 shillings 5 pence per ton-mile.

Import goods, just double.

First, second and third class fares, at 600, 400 and 200 reis, respectively, per Brazilian league.

Brazilian currency is the milreis ($), whose value varies with the exchange. Its present value is about 15 pence, or about 30 cents in United States money, which I have used in all the following conversions. One thousand milreis are a "Conto" of reis (:). These values apply to the milreis, paper, unless otherwise specified, the value of the milreis, gold, being 27 pence.

Should the companies' dividends surpass 12 per cent. (and this has, in many instances, proved to be no idle clause), tariffs should be reduced; if comprised between 8 and 12 per cent., half the corresponding earnings should be refunded to the government in repayment of interest guarantee received.

A curious clause stipulates that all Brazilians in the company's service would be exonerated from military and guard duty. The use of slaves was prohibited, though slavery had not yet been abolished.

I have quoted the principal clauses of this law because the subsequent railway legislation has only modified the original law, without any new departures.

These terms were tempting, and many railways were granted in compliance with them.

The following companies were incorporated (quoting only such lines as have been built):

Recife & Sao Francisco (now part of the Great Western Railway);

Bahia & Sao Francisco;

Santos & Jundiahy (now the Sao Paulo Railway Company); all three English companies; and, finally,

The Dom Pedro II. Railway, a Brazilian company floated by the Viscount de Rio Bonito, taken up by the government in 1865, and which is to-day the Central Railway of Brazil.

These, with the Rio Claro Railway, form the broad-gauge system of Brazil. This gauge had been stipulated, in the 1852 law, 5 feet 6 inches originally, which was soon reduced to 5 feet 3 inches.

All these lines start from the coast and run inland, which is still the general characteristic of Brazilian railways, and the reason the development has been so slow and difficult. There is a formidable barrier between the sea and the uplands, the continuous Sero do Mar stretching close to the coast from the north all the way to Porto Alegre, near the frontier of Uruguay in the sóuth, thus rendering the first section of the railways the most costly of the system. Conversely, important harbours are rare and far between, exportation depending on the ease with which agricultural produce from the inland provinces can reach the coast.

Natal is the most northerly of these harbours, and is followed by Recife (also called Pernambuco), Bahia (or Sao Salvador), Ilhéos, Victoria, Rio, the capital, with Nicteroy opposite, Santos, the harbour and seacoast town of the State of Bao Paulo, and Rio Grande do Sul (also called Sao Pedro).

These are the more important of the natural harbours, and the government early perceived the necessity of making inland railways start from each of them.

The natural development of the country has followed, and traffic in-

creased to such an extent that the early harbors have become insufficient, and all of them have had to undergo a number of improvements; some are now in course of construction, the others will be so shortly. The life of each of these harbours is so tied up with that of the railway system it serves that it is impossible to examine the one without examining the other; we will, therefore, take them together.

Broad gauge had been decided upon at the very outset, which in such a country as Brazil is a pity. This is one of the reasons railway progress was so slow originally; there is no doubt about that. The land was new, capital shy, building costly. The metre gauge would have suited the country's requirements far better, especially at the outset; and its extraordinary development and the railway system's quick growth as soon as the government substituted the metre to the 5-foot 3-inch gauge bear witness to the fact. A few of the older 5-foot 3-inch gauge lines, thus isolated, have actually been converted back to the metre gauge, and a small system of a few trunk lines is all that remains of the broader tracks.

On April 29, 1852, Viscount Maua floated a company for building a railway from Maua, on the Bay of Rio, to the foot of the neighbouring hills, the Serra de Estrella. This is the first line to have been opened to traffic in South America, and that without a guarantee of government aid of any kind. The extensions up the hills of both this and the Nicteroy lines were wisely laid to the metre gauge and the original lower sections eventually narrowed.

The Maua line was followed at a very short interval by the Uniao Valentiana line, technically the worst of Brazil. It was laid to 1.10-metre gauge (3 feet 7¼ inches), which it has, so far, been alone to retain. This railway was built with funds loaned in part by the State and in part by the large landowners.

Its curves are sharper than those of any other road in the country, 237 feet radius being not uncommon, while the gradients reach 1 in 28. Luckily, it is not a long line, running from Desligado, a small station on the Dom Pedro II. Railway, due north to the frontier of the State of Rio, on the banks of the Rio Preto. It is this fact, coupled with the one that the Valentiana Railway has never been extended beyond its original terminus, that shows that the frontier of the State follows the Rio Preto, and not the Parahyba, some thirty miles to the south, as half the government maps show, either.

Such was the immediate success of both lines that they were followed by a number of others, granted by the provinces; and as they have formed the backbone of the whole system, it is interesting to quote them. I would add that not only were railways built under these bills, but also under a number of others, the principal ones of which I will quote.

In the State of Rio the Cantagallo Railway was conceded in 1856, the Sao Antonio de Padua Railway in 1872, the Machhé & Campos Railway in 1870; these three roads are the earliest sections, with the Maua Railway, of the important Leopoldina Railway Company.

The Rezende & Areas Railway was granted by the same State in 1872, and has remained a small, independent concern, which is a pity, as it might otherwise have reached somewhere.

In the State of Pernambuco, the Pernambuco & Limoeiro Railway was started in 1870, and has since become the Great Western Railway. The Caxanga Railway was started in 1863 and the Olinda & Berebibe in 1868. Here, again, is the original gauge mistake, from which hardly a country has been free: each of these three lines has been built to a different gauge. It is difficult to realize to-day that the original promoters never realized this blunder.

The Central of Bahia Railway was begun in 1866 to a different gauge again—3 feet 6 inches—the only one in Brazil, and has not been converted yet, owing to no connection with any other railway having been established.

In the south, the State of Sao Paulo conceded a line to the Paulista Railway in 1862, to the Sorocabana in 1870, and to the Mogyana Railway that same year; these three roads have developed into important railway systems, aggregating the largest mileage in Brazil.

The State of Parana started the Paranagua & Curytiba Railway as far back as 1872, and the two oldest lines of the State of Southern Rio Grande were begun in 1869 and 1870 from Porto Alegre. the chief town, to Novo Hamburgo, and from Rio Grande, the principal harbour to Bagé, a large inland town and important smuggling centre.

All these lines are now in operation; the trouble has lain in uniting them.

The next new departure was made by the State of Minas Geraes in granting the Leopoldina Company a subsidy of 9,000$ per kilometer of new line (about 14,481$ per mile), instead of a guarantee of interest. This law, a mistake in itself, served its turn, and though some railways were undoubtedly built for the sole purpose of being paid the subsidy, they *were* built; on the other hand, most of them are uselessly long and circuitous. This same mistake has been made in Spain. A further trial of the system was made on the West of Minas line, also in the State of Minas, between Sitio and Sao Joao del Rey, the first section of a long inland-penetration line. The Bahia & Minas Railway and a few others in the State of Rio followed, and the system was sanctioned thereafter.

In 1873, 639 miles of railways had been opened to traffic; but there was still a knotty point: should the metropolitan government or should the provinces concede the lines? A number of bills were passed between February, 1874, by the Empire until June 26, 1890, by the Federated States, all allowing either to concede railways in specified instances. The latter bill decided that the metropolitan government should grant all railways:

(a) That connect Rio, the capital, with the capitals of the States;

(b) That connect Brazil with the neighbouring republics;

(c) That are useful for military purposes.

The States may grant extensions, provided the government has no intention of so doing. When granting inter-State railways the States must consult the government about the gauge and some other points. The government also decides in all questions relating to any railway within a hundred-kilometer zone (62½ miles) of the (a), (b), or (c) lines.

In the meantime, the legislation for the government concessions had undergone gradual alterations.

The law of February 18, 1874, stipulated such concessions should be perpetual or temporary, and not longer than ninety years in this case, after which time the railway would revert to the nation.

On August 10, 1878, another law was edicted, stipulating all concessions should be temporary.

The early steps had to be paid for, of course, and each successive law brought some correction to the former one.

The original six-league guarantee (41 miles) was reduced to 60 kilometers (37½ miles) in 1874 to 25 miles in 1878, and to half that afterwards.

In the same way the duration of the government guarantee of interest was reduced from ninety years at the outside in 1874 to thirty years in all concessions granted after 1878. The way this guarantee was calculated has altered as well; the 1874 law contained a clause stipulating this guarantee should cover the original capital after readjustment when the

building accounts were closed; the 1878 law was based upon a thoroughly different principle: the original estimates and survey having been approved of by the government, the guaranteed capital expenditure was, therefore, unalterable. Both systems had their drawbacks; in the first case, the guaranteed capital expenditure sometimes far exceeded the amount it was the government's wish to cover, and in the second case the guarantee might cover quite a different amount to that which was really expended, which was either to the company's or to the government's detriment.

The interest, government's guarantee, carried has varied, of course, with the financial condition of the market. Originally 7 per cent., it has fallen to 6 per cent., gold or paper, and quite recently to 5 per cent., gold.

The guarantee system is a costly one; the government has, therefore, endeavored of recent years to do away with it, and few new railway undertakings are likely to be granted such guarantees in the future. Of course, when a new line is deemed necessary across a poor country or to open up new districts to civilization, such guarantee is often necessary; but even then other ways are being tried. Whenever the government has been able to do so the lines with a guarantee have been bought back or otherwise incorporated, and leased again on other terms either to the same or to other companies.

A few years back practically all lines had a guarantee. On January 1, 1908, eleven lines only still have a governmental guarantee, all 6 per cent., gold or paper, except the Campanha line, 4 per cent. only.

The gold guarantee applies to six of them, aggregating 557 miles.

The paper guarantee, to five lines and 396 miles.

All these lines are worked at a loss. Here is a list of them:

GUARANTEED RAILWAYS IN BRAZIL.

LINE.	Miles open.	Kind of Railway.	Ratio exp. gross earn.	Guarantee.	Government Liability. £ Sterling.
Victoria Diamantina	130	penetration	116,11	6% gold	113,314
Sao Paulo & Rio Grande	261	connection	135	6% gold	131,500
" branch	...	penetration	building	6% gold	26,312
North Western Railway	51	penetration	231	6% gold	55,564
Goyaz Railway	...	penetration	building	6% gold	19,725
Quarahim & Itaquy	109	strategical	99,5	6% gold	40,500
Alcoçaba Praia da Rainhas	...	transrapids	building	6% gold	9,618
					£385,525
Caxias Cajazeiras	49	transbasin	119,34	6% paper	8,305
Lepoldina Company, 3 lines:					
Barao Araruama branch	32	extension	192,8	6% paper	5,793
Central Macahê Ry	27	development	200,4	6% paper	4,488
S. Eduardo Itapen	58	extension	132,4	6% paper	10,489
Muzambinho Ry. Campanha branch	54	development	168,6	4% paper	6,274
Mogyana Ry. Araguary line	176	penetration	111,3	6% paper	31,838
					£67,847

The paper guarantee liabilities are stated in milreis, and have been converted in the above table at the rate of 15*d.* per 1$.

The fact of the expenses being so much heavier than the earnings is no proof of the government's subsidizing bad or useless lines only. A number of them are either penetration lines, or connections that are an indirect source of revenue to the State in opening up new districts.

The expenses due to interest guarantee have slightly increased during the past year and reached 1,814,500$, paper (£113,406) and 4,904,063$, gold (£181,632), owing to the increase in several of the subsidized companies' capital.

Up to 1899 a number of lines had been built connecting towns or convenient districts with each other, all isolated undertakings.

There was no governmental railway policy besides the complication arising from having metropolitan government concessions or leases (called lines of the "Union") and others granted by the States.

A Railway Commission was appointed on May 3, 1890, for drawing up a general plan of the railways that should be built and turning the whole system into a sound and useful one. This was all the more necessary as Brazil has a unique system of waterways: the basin of the Amazon extends right up into Matto Grosso and Bolivia, where the Rio Paraguay's tributaries start, forming a magnificent and nearly unbroken inland water communication across pretty nearly the whole continent. Besides these, a number of powerful rivers lead down to the Atlantic; and when there is still such a vast system of railways to build, the navigable streams show not only which lines need not be built in the immediate future, but also which should be, for connecting two such rivers.

The Commission sent in their report, which was adopted. All the lines the Commission recommended have been built, or are building, sometimes in a slightly modified form; but as the railway building scheme now in hand is the outcome of the 1892 report, the new lines the Commissioners asked for are interesting to quote.

The ruling idea was to unite the existing systems, to build a few long penetration lines into suitable districts, and to complete the military or "strategical lines." Most of the penetration lines were to continue those starting from the coast of Sao Paulo and Rio States and to reach some tributary of the Northern, Amazon or Paraguay watersheds.

Among these the line to Catalao from Barra Mansa is one of the foremost. There has been a good deal of subsequent trouble about this line, which has changed hands several times, and though Goyaz, with its pastures, its excellent climate and its gold mines, seems to be one of the most promising parts of Brazil, no railway has yet opened up connection with Catalao, though several are now in course of construction.

The northern isolated lines were to be lengthened and united; these connections are being proceeded with now.

The principal strategical lines were destined, of course, to carry troops easily to various points of the frontier. These are the Pelotas and Jaguarao branch, just surveyed; a line from Cacequy to Rivramento, about to be opened to traffic, and from Cruz Alta to the Uruguay River, building. These three roads run to the southern frontiers of Brazil. A fourth was to connect Guarapuava, in the Parana State, with the mouth of the Iguasu and Corumba, on the frontier of Bolivia.

Should Brazil wish to garrison the Bolivian frontier, she must now send the troups around the southern States, down past Uruguay and up the Rio de la Plata and Parana, in the Argentine Republic, until Corumba is reached. It has since been found expedient to shift the starting point of the new line to Bauru, in the State of Sao Paulo, and is already quite a distance inland. The North Western Railway runs from Bauru to Itapura, and will reach Corumba shortly.

Other connections were advised and a railway to the frontier of British Guyana proposed because, said the report, "having been informed that on the boundaries of Brazil with British Guyana the natives were taught English, and that, accordingly, they became identified with that nation; and led also by recent events which showed clearly the ambition of European nations regarding territorial possessions, the Commission thinks it is of the utmost importance to nationalize these remote regions as soon as possible, and earnestly calls the government's attention to this point."

In 1892 the Department of General Railway Inspectorate or "fiscalization" was formed. There are seven fiscalization districts, of very unequal importance:

(1) Para, Maranhao, Piauhy and Ceara.

(2) Rio Grande dol Norte, Parahyba, Pernambuco, Alagoas.

(3) Sergipe and Bahia.

(4) Espirito Santo, Rio, Minas and Goyaz.

(5) Sao Paulo.

(6) Parana, Santa Catharina.

(7) Rio Grande do Sul.

At the time (1892) the development of the railways was at follows:

	Miles		
	Subsidized	Not subsidized	Total
Open to traffic....	1,849	979	2,828
Building	2,249	228	2.477
Under survey	3,964	723	4,687
In project	3,458	3,442	6,900
	11,520	5,372	16,892

There had been a regular railway craze, and privilege lines were becoming the exception. The protected zone had dwindled and disappeared; so had the guarantee of interest in many cases. But the first fruits of the revolution were the upsetting of all the economic rules of the country and that terrible slump in the exchange from which it has never thoroughly recovered. The railways were badly crippled, and the revision of tariffs was the consequence. The outcome was an increase in the rates up to 30 and 40 per cent. The railway industry revived and has prospered.

The government, besides, has wisely done all that lay in its power to people and colonize the vast tracts of uninhabited or sparsely inhabited land. Railway companies are now obliged to build "colonies" along their lines, in conformity with the clauses inserted in the recent contract with the Sao Paulo & Rio Grande Railway Company. These colonies should be in suitable situations, about 13 miles apart. The company purchases the land at a nominal fee when it is government's property, and may expropriate it should it be necessary to do so. Advertisements in Europe tempt immigrants, whose passage to Rio is paid by the Brazilian Government. These immigrants are given the land free, and are helped by the railways in a number of ways: 50 per cent. reduction on all rates during five years and a stipulated number of days' work each year upon the railway. They are provided with seed for their fields, medicine if they are ill, etc., free. On the other hand, the government pays the company a premium of 200$ (£12 10/-) for each new house erected in the "colony," 100$(£6 5/-) per family living on the colony more than six months, and 5 contos (£312 1/-) per group of fifty lots of ground where immigration has definitely settled into landed property.

On January 1, 1909, the railway system of Brazil was made up as follows:

THE RAILWAYS OF BRAZIL.

	Miles.			
RAILWAYS.	Open.	Building.	In project.	Total.
Government owned and worked........................	2,126.2	1,038	561.8	3,726
Government owned and leased........................	3,057	229.4	362.2	3,649.6
Private lines, conceded by Government, with guarantee..	1,457	592	617	2,666
Private lines, conceded by Govt., without guarantee....	1,155	51	828.4	2,034.4
Private lines, conceded by the States................	3,851	456.8	1,131	5,428.8
Total..	11,646.2	2,357.2	3,501.4	17,504.8

Another 357 miles was opened to traffic on April 1, 1909.

The large mileage of government roads is due to many causes. In compliance with the general railway scheme of 1892, the government built a number of lines. Then most lines having a governmental guarantee have been bought up; besides which, when companies became financially involved, such as the West of Minas Railway, the government incorporated them and endeavoured to form them into systems having a better prospect of success.

Finally, the old Dom Pedro II. Railway, now the Central Railway of Brazil, has been nationalized.

All these lines are formed into systems and leased.

Besides the usual clauses as to rentage, taxes, and often the building of extra branches and extensions, they must now provide the trains and stations with refrigerators and run dining and sleeping-cars of "the most modern design."

There is no present likelihood of leasing the Central Railway, one of the most important of Brazil, as it is the government's intention to keep it as a training school for its engineers and as a useful political tool. Several new lines have not been leased yet, but are likely to be leased shortly—as soon, in fact, as they turn out paying concerns, or upon completion. The enthusiasm for the government's "connection scheme" has been out of all proportion to its immediate usefulness; it seems to have been the outcome of some sort of popular feeling for consolidating the unity of the Brazilian Republic.

The State railways are now the following:

The Central of Brazil Railway, from Rio to Sao Paulo and northward; the West of Minas, in that State; the Rio do Ouro Railway and the Dona Thereza Cristina Railway, two small lines, both costing a horrible amount to work.

Besides these lines, all of which are owned and worked by the government, the Railway Department is building the following, in compliance with the 1892 scheme:

The Madeira & Mamoré Railway;

The Sao Luiz & Caxias;

The Baturité and the Sobrl extensions;

The Timbo & Propria.

All these lines are up north. Besides, the Cruz Alta & Ijuhy is under construction by the War Department, and the Loreno to Barreiros line is in the hands of the military authorities.

Most Brazilian railways are metre gauge; but the curves are often too sharp and the gradients too steep for lines that should be looked upon not as light railways, but as the standard gauge lines of a continent. It is mistaken policy to exceed 1 in 40 gradients and 400-foot radius curves, with exceptions, of course.

Should branches allow it, these limitations could be surpassed.

Metre gauge rails should not be too light, either, especially as stone ballast is still the exception; they should never be lighter than 45 pounds a yard, as they otherwise hamper the road's development in no time. A 60-pound rail will be found the best all-round rail in Brazil.

All the rolling stock should be, and the majority is, made up of bogie stock. The passenger engines are Moguls (2-6-0), ten-wheel (4-6-0), or even Pacific (4-6-2) locomotives. The American type metre gauge locomotive (4-4-0) has too little power. Consolidation locomotives (2-8-0) are the best metre-gauge lines goods engines, save when extra power be required.

Such is the outline of the Brazilian railway system, a still heterogeneous mass of Government, State and even municipal railways, the municipality being very similar to the British county.

Another complication is due to the fact that each of these works some and not all the lines it concedes and leases the remainder without or with a guarantee of interest. But we cannot over-much criticise this variety, as it is absolutely similar to our own practice in India, where we also have State railways, some of which only the State works, then the native States lines, and the private companies, and where, moreover, the "assisted" railways are similar to Brazil's guaranteed or subsidized lines.

It is, therefore, a mistake to examine the railways of Brazil in a group, as one would those of Italy or of Germany. Brazil is hardly smaller than the whole of Europe or the United States, and is made up of a number of very autonomical States, absolutely different and separate in every respect from each other. The whole of the basin of the Amazon,

for instance, is practically devoid of railways, though it covers pretty near the two-thirds of the country.

The railways are distributed as follows:

State.	Area.	Population, 1909.	Railways. Miles.
Amazone	712,362	240,000	.....
Acre Territory		41,200	.....
Para	431,735	652,400	109
Maranhao	172,693	660,000	49
Piauhy	153,369	425,000	.....
Ceara	39,147	1,000,000	340
Northern Rio Grande	21,580	407,200	104
Northern Parahyba	28,062	408,500	152
Pernambuco	48,214	1,115,000	566
Alagoas	21,964	649,300	166
Sergipe	14,678	373,100	.....
Bahia	160,150	2,335,000	820
Matto Grosso	518,083	157,000	.....
Goyaz	280,627	340,000	.....
Minas Geraes	215,870	4,277,400	2,517
Espirito Santo	18,875	201,600	289
Rio and Federal District	26,420	1,880,000	1,648
Sao Paulo	108,800	2,567,000	2,617
Parana	83,100	360,000	566
Santa Catharina	21,840	405,800	109
Southern Rio Grande	88,830	1,350,000	1,133
	3,130,761	19,155,000	11,185

Thus the east coast States alone have the enormous share of 11,185 miles, and the northern States have none to speak of. Rio and Sao Paulo take the lead, and are followed by Minas and Rio Grande do Sul. Next come Bahia and Pernambuco, and, with a lesser amount still, Parana and Santa Catharina. And that is practically all.

Compared to their population, the order is the same—all but Parana, with 566 miles of railways for 360,000 inhabitants, and Espirito Santo, with 289 miles for 201,600 inhabitants. Apart from these two States, no State in Brazil has a mile of railway per 1,000 inhabitants, owing to their great dissemination, and the whole of Brazil has not half that.

The United States of America have about twenty times the railway mileage of Brazil per square mile and five times the mileage per 1,000 inhabitants.

The comparison with Europe is less to Brazil's advantage. Europe has about four times the population of the United States and a lesser railway mileage.

But all these railways have many points of interest and a brilliant future before them. They are still developing rapidly, and in the following pages I intend giving a general description of these railways, being very sober with regard to the new lines. Until such lines are actually opened to traffic they keep on altering, so I will only quote such lines as are an almost absolute certainty.

All these railways can be grouped into five parts:

(1) The Northern system, covering the Amazon basin and the northern rivers. This group is mostly building, and comprises a number of small roads: the Sobral, Baturité, Madeira & Mamoré, etc.

(2) The Great Western Railway system, in the small northeast States.

(3) The Bahia group: a number of nearly amalgamated lines in the north (Central of Bahia, Bahia Sao Francisco, Timbo & Pripria), and the Victoria & Minas in the south.

(4) The central group, the most important of all, and a complete network in itself. It covers the States of Rio Minas and Sao Paulo, and comprises principally the following railways:

Central of Brazil and Leopoldina Companies, starting from Rio; West of Minas (and Goyaz extension) and the new South Minas Railway; and in Sao Paulo, the San Paulo Railway to the capital, and the three important companies: Mogyana, Paulista and Brazil Railway, the latter stretching to the limit of Southern Rio Grande.

(5) The Rio Grande system, almost inseparable from those of Uruguay and of Entrerios.

(To be continued.)

Current Topics

ONE of the difficulties continually occurring in connection with any effort to remedy existing conditions in any department of life appears in the unwillingness of a large part of the community to admit that a change in the present state of affairs is to be considered. Innovations are condemned because they are innovations, and have a hard time in being considered on their merits, while any radical modification in ancient methods is resisted without reason or judgment.

Thus, the introduction of high-speed motor vehicles on existing highways is met by attempts to regulate their movements, and, in most instances, to deprive them of a large part of their advantages in the endeavor to make them conform to the limitations of the vehicles of less power and lower speed already in use. The idea that the great advantage of the improved means of transportation should be utilized by providing a clear way for them seems altogether secondary, and a disposition to obstruct and to impede progress comes immediately to the front.

Such a policy would have deprived the community of all the enormous advantages which have followed from the development of steam railways, and would have bound us to the inconveniences of the stage coach, the canal packet and the post chaise. It would have prohibited the electric railway and the motor 'bus, and it would have impeded the progress of the telephone and the aeroplane.

When a conflict arises between the old and the new, it may well be understood that a law which, while of comparatively recent discovery, has been of eternal existence—the law of the survival of the fittest—is certain to make itself observed. The unfit and the obsolete must give way, not necessarily to their own destruction, but certainly to the termination of their former dominion. In the case of the dominance of the motor car, we may recall the incident in the early history of railways when George Stephenson, appearing before a Parliamentary committee, was asked if it would not be very awkward if a cow should get on the tracks in front of a locomotive, and replied that it would be very awkward indeed "for the coo"! The pedestrian has already found it very awkward for himself in crossing the highway filled with rapidly-moving automobiles, and if he would but realize that he is powerless to oppose the increasing numbers of the speedy and powerful machines he

might be induced to grasp the imperative necessity of providing for himself a highway entirely apart from that which he formerly controlled, and thus eliminate wholly the questions which have arisen because of more recent developments.

A similar situation is doubtless impending in connection with the general introduction of aerial navigation. Real property rights, as they have been termed, may well be considered as coming under the definition that property is that which one is in a position to defend. Nominally, its limits may be taken as extending downward to the centre of the earth and upward to the skies; actually, no man can intelligently hold himself to be the owner of the space above his house through which an aeroplane goes speeding without so much as saying "by your leave."

When these conditions, to say nothing of others, are grasped, it must be admitted that the work of the engineer is forcing a revision of the older principles of ownership which have hitherto been accepted. This does not mean that confiscation of existing rights is impending, but it may be understood to involve such a modification of former rules of conduct as shall permit the best development of the benefits of invention and of scientific discovery.

ATTENTION is called to the report of one of the English engine and boiler insurance companies to the bad design of some vertical air pumps. One of the troubles is the great space between the top of the bucket and the delivery valves. This is often several inches, and it represents so much resistance against the lifting of the valves to admit air and water from below.

Then there is often a considerable slope from the base of the condenser to the base of the pump, and water will collect in this deep space to a depth of several inches, thereby locking up air in the condenser. The foot valve of an air pump is sometimes of considerable weight, and this is a further obstruction to the free working of the pump. In one case investigated the total resistance to the escape of air from the condenser amounted to 50 inches. Under these various conditions the working of an air pump cannot help but be very irregular. Sometimes the air is walled back by the intervening water. Next, a way is broken through and the air escapes. While all this is due to bad design, and should be avoided from the start, yet some remedy may be effected by leading a small pipe from the condenser so as to enter the air pump just at the level of the water seal upon the bucket when the bucket is in its lowest position. By this pipe the air will rush from the condenser into the nominally perfect vacuum above the bucket. More than this, the air now drawn in below and through the bucket will be reduced, if not quite abolished. With several inches of water on a bucket, any air which passes through the bucket must be considerably delayed. Much of it may fail to reach the surface of the water during the upstroke of the bucket, so that there is air remaining in the pump when the bucket begins to descend, and this air quite prevents the formation of a really good vacuum on the next down stroke. It must, undoubtedly, often be the case that the charge in the pump is not separated into distinct layers of water and air for separate delivery. When an air pump is acting at its best, the bucket first pushes air through the delivery valve, and next it discharges foam, which gradually passes to solid matter. Should such a pump be run a little faster no solid matter even will be discharged. The discharge will not extend below the foam stratum. This is why an air pump may sometimes be improved by reducing its speed so as to permit of better and more complete separation of air in the water seal.

The best bucket has a flat upper face and no through valves. It is a solid bucket, which goes down below the port openings and admits water above itself, acting as its own valve. Such, with special shape of base and foot passages, is the Edwards pump; but any air pump may be made solid and with the ring of ports for water to enter above, and not through, the bucket. There is but little time, of course, for the water to get within the area of the barrel of the pump during the brief period which the bucket spends below the port level. Perhaps this difficulty underlies the mechanical propulsion of the water by the conical base of the Edwards type bucket. This gives a high-velocity propulsion to the water, which is shot rapidly through the ports and effectually does get a charge of water into the pump. It is responsible for a good deal of splash and foam, and the high speed rendered possible by the rapid entry of water is, perhaps, limited by the foam formation and the non-separation of the air before the bucket reaches its top position. Hence the need for small clearance above the bucket, so that if a solid layer of water does form upon it the clearance shall be less than the depth of the solid water. There is, then, something to be said for moderate speeds, and, as with other matters in mechanical engineering, the most satisfactory design is one in which conflicting conditions are best compromised into a fair general harmony.

WITH the present talk about gyroscopes there is accruing the usual misconception of the average man. It is being said that the gyroscope will keep, say, a torpedo in a straight course, and this is largely true. But it is not true that when the torpedo has been deflected it will return to its original course. This is quite erroneous. A gyroscope, by its action, opposes a powerful resistance to any force tending to cause it to rotate in a different plane. But if a force is applied sufficient to put the gyroscope in another plane of rotation, the motor will then offer an equal resistance against being moved from that plane also. It will, in fact, always endeavor to maintain a straight course; but when put out of it by a superior force it will accept the situation and abide by it. Its value evidently is in reducing the deflections that external small forces may exert. But obviously regarding a gyroscope as intensified mass, any external deflecting force being sufficiently applied will produce movement—that is to say, will change the plane of rotation of the gyroscope. The gyroscope is not an absolute preventer of deflection; it is merely a reducer.

THOSE interested in the mechanics or engineering of ordnance should study Sir A. T. Dawson's lecture (the Gustave Canet Lecture), for it contains much that is of interest, both historically and mechanically. The modern gun is the child of the metallurgical art: for, owing to the advances in that art, guns yearly grow more powerful per unit of weight. Even up to 1840 cast iron was a gun material. Then came the steel tube with wrought iron hoops shrunk on. The boring of the hoops correctly to size gave opportunity for good machine work; but material was faulty even in 1864, chiefly because it was sought to make steel of too high a tenacity, and it would fly to pieces. Now that steel is reliable, it is not used for this system of construction by shrinking on heavy rings. The modern gun is wire-wound, the winding being put on at a certain calculated tension. The gun of to-day is an engine of precision, as may be told by the naval shooting records. Not only must the gun itself be accurate, but its charge of explosive must develop a certain definite force, or a shot could not be put into the few feet area of target which can now be hit at long range time after time.

WALTER M. McFARLAND

A BIOGRAPHICAL SKETCH

IT is an interesting fact that the Engineer Corps of the United States Navy has furnished to a number of great manufacturing establishments some of the ablest men who have been placed in charge of technical and commercial administration. The subject of our sketch this month is an excellent example of the manner in which individual ability, combined with the engineering training of the Navy Department, has advanced in civil practice and resulted in a degree of success which demands especial notice.

Walter M. McFarland was born in Washington, D. C., in 1859, and received his education in the public schools of his native city, in the preparatory department of Columbia University, and at the United States Naval Academy at Annapolis. It was in 1875 that he entered the Naval Academy as a cadet engineer, and in 1879 he was graduated second in his class. He was commissioned as an assistant engineer in 1881, and after a wide experience in sea service he was detailed to the Bureau of Steam Engineering in 1882. From 1883 to 1885 he was detailed from the navy as assistant professor of mechanical engineering at Cornell University, and during the years 1885 and 1886 he was occupied with the inspection of machinery under construction and with work on preliminary design for proposed vessels. From 1889 to 1894 he was again attached to the Bureau of Steam Engineering, having been commissioned as Past Assistant Engineer in 1891. In 1898 he was made Chief Engineer, being the youngest officer for more than twenty years who had received this grade.

In 1897 the subject of the personnel of the United States Navy was under special consideration in connection with proposed legislation, and the personnel board was assembled by the Secretary of the Navy to consider and report upon the question. Mr. McFarland was made a member of this important board, and had the honor of acting as the sole sponsor for the younger men of his corps. From the first he was one of the most active and efficient supporters of the amalgamation scheme, the recommendation of which was the main result of the deliberations of the board. As a member of the board he had the special confidence of its presiding officer, Theodore Roosevelt, then Assistant Secretary of the Navy, and he proved a powerful advocate of the measure before the Congressional Committee, drawing from them the comment that he was the best-posted man they had ever examined.

After the passage of the "personnel bill" Mr. McFarland was commissioned Lieutenant, and in the same year he resigned from the naval service to enter the employ of the Westinghouse Electric & Manufacturing Company as acting vice-president.

During the ten years in which he has held the responsible charge of the work of this important business he has had official supervision of the large contracts of the company, besides acting as the advisory head in all the co-operative movements of this company with the associated Westinghouse Companies in connec-

tion with literature, advertising and exhibition work. He is well known as a frequent representative of the Westinghouse Companies at important meetings of engineering societies and conventions, and has long been regarded as the official host of the company at Pittsburg.

On April 1, 1910, Mr. McFarland severed his connection with the Westinghouse Electric & Manufacturing Company to accept an official position with the Babcock & Wilcox Company, having his headquarters in New York City. His wide experience in naval and marine affairs, as well as in general engineering, renders him especially available for the conduct of a business relating to the generation of steam, and particularly in the department of marine boilers, and thus a field uniting much of his previous experiences is now open before him.

He has been a frequent contributor to the technical press, and the readers of this magazine will remember his paper upon "The Commercial Side of Engineering," in which he emphasized the important fact that a thing should not be more costly than the operative conditions demanded, and that in most instances the saying, "the best is good enough," should be replaced by its reversal, "good enough is best."

Mr. McFarland is a member of the American Society of Mechanical Engineers, and served as vice-president from 1905 to 1907, and at the present time he is vice-president of the Society of Naval Architects and Marine Engineers. He is also a member of the Engineers' Club, of New York; the Duquesne Club, of Pittsburg; the Army and Navy Club, of Washington, and the Army and Navy Club, of New York.

A. FREDERICK COLLINS

See page 191.

CASSIER'S MAGAZINE

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THE RAILWAYS OF BRAZIL

By Lionel Wiener, Technical Secretary to the Rio Grande do Sul Railways

II. THE NORTHERN RAILWAY AND RIVER SYSTEM

The introductory article of this series, published in the May issue of this magazine, describes the general conditions under which railway development has taken place in the United States of Brazil, and the plans which are now under consideration for the extensive construction of lines which will open to the commerce of the world a country nearly as large as the whole of Europe. The present paper, and those which are to follow, discuss in detail the various systems and show the enormous opening now already available for British and American capital, and the extent to which these opportunities are already being grasped. Brazil probably offers one of the greatest examples of undeveloped natural resources of any portion of the world, and the construction and operation of the various systems described in these papers will render it one of the most accessible.—THE EDITOR.

THIS system is the smallest railway and the largest river system of the whole of Brazil. It is hardly a system at all, in fact, as most lines are still unfinished and unconnected. But, in my opinion, it is just now, perhaps, the most interesting to Europeans, and, though its few lines are widely dispersed, it covers an enormous and rich tract of country: the Amazon, Grao Para, Goyaz, Maranhao, and Piauhy States, which are overgrown with forests of valuable timber and crossed by the most magnificent of waterways, the Amazon and its affluents.

This is a portion of South America that awaits only the building of a railway system to be opened up and for people to come to live in it; and here, of all places, is an opening for foreign capital and activity.

The Amazon and its principal affluents are navigable, and several steamboat companies run up them at regular intervals; several are subsidized. Considering these as main lines, it is necessary to build two classes of railways: the first for connecting the lower and the upper reaches of a river broken by shoots, rapids, or shallows, which we will call "trans-rapids lines"; the second, for connecting a town or place of some importance with a neighbouring one situated on an adjacent stream; these are the "trans-basin railways."

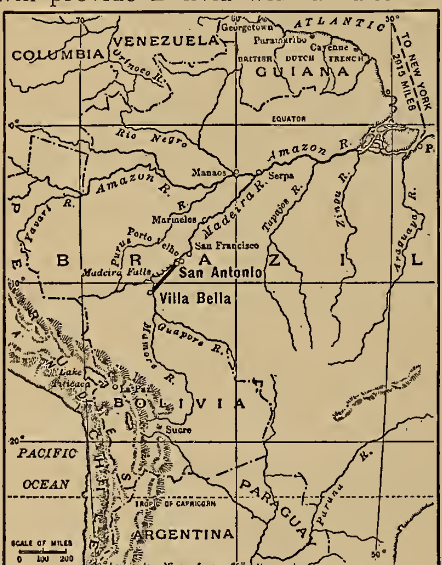
Now all important affluents of the Amazon are navigable all the way up-stream without a break, with two exceptions, the Madeira and the Tocantins.

The Madeira is navigable up to Sao Antonio, 2,500 miles of unbroken navigation. Then there is a stretch of rapids and of falls up to Paçanova, and beyond, an enormous upper watershed comprising the Upper Madeira, its large tributary, the Mamoré, and many other rivers adding several hundred miles of navigable waterways.

The Madeira and Mamoré Railway is a trans-rapids line, 216 miles long, that will connect these naviga-

ble rivers with each other. It is now building to the meter gauge across a most unhealthful stretch of land, and might have been given up were it not that the Treaty of Petropolis, between Brazil and Bolivia, obliges the former to build the line. The Guaporé, a frontier-stream, runs into the Mamoré, whose course lies for a considerable distance in Bolivia, as do that of the Beni and the Inambari.

Bolivia has only a westerly outlet to the coast; the portion east of the Andes is shut off. The completion of the Madeira and Mamoré Railway will provide Bolivia with an alternative route; an almost unbroken waterway all the way to the Atlantic, benefiting not Bolivia only but the Matto Grosso as well.



Courtesy of *The World's Work*.

THE RELATIONS OF THE MADEIRA-MAMORÉ RAILWAY TO THE EXTERIOR WORLD

The line will cost the government more than £2,000,000. It is leased to the Madeira and Mamoré Railway Company for sixty years, on condition that the company pays the government in addition to one-fifth the net earnings above what is necessary for paying 12 per cent. dividends; 5 per cent. of the gross earnings during the first twenty years; 10 per cent. during the second score of years, and 20 per cent. during the third score.

More than forty-five miles of the Madeira and Mamoré Railway are already constructed, and the entire line will be opened by the close of 1911. The region opened up by this railway is a particularly rich one, especially in rubber and other tropical vegetation. In spite of the high cost of transportation, now about £50 per ton, due to carriage along the 200 miles of roadway before the completion of the railway, a large amount of rubber is already exported from this district. The Aore Territory, recently sold to Brazil, already pays in taxes close upon £1,000,000, which gives some idea of the importance of the traffic to be anticipated.

The Amazon Steam Navigation Company carries material for the railway at a reduced rate of freight; £7 18*s*. 8*d*. for a ton of iron, £9 1*s*. for a cubic metre of ironmongery, and 14*s*. for a thousand brick.

North of Brazil Railway. — The next break of navigability is that of the Tocantins—not far from its mouth—between Alcobaça and Praia dá Rainhas, where the North of Brazil Railway Company is building a line. The work is easier because it is nearer the coast than is the Madeira and Mamoré Railway, and the country is less unhealthful. The total length is 115 miles, and all are about to be opened to traffic.

When the line will have reached Praia dá Rainhas the whole of the State of Goyaz, except the very south, will have easy communication with Belem, while the new Gayaz Railway will reach the Araguay river from the south Rio and Sao Paulo.

This long line is entirely in the hands of the North of Brazil Railway Company, the successor to the "Tocantins and Araguay Rail and River Company."

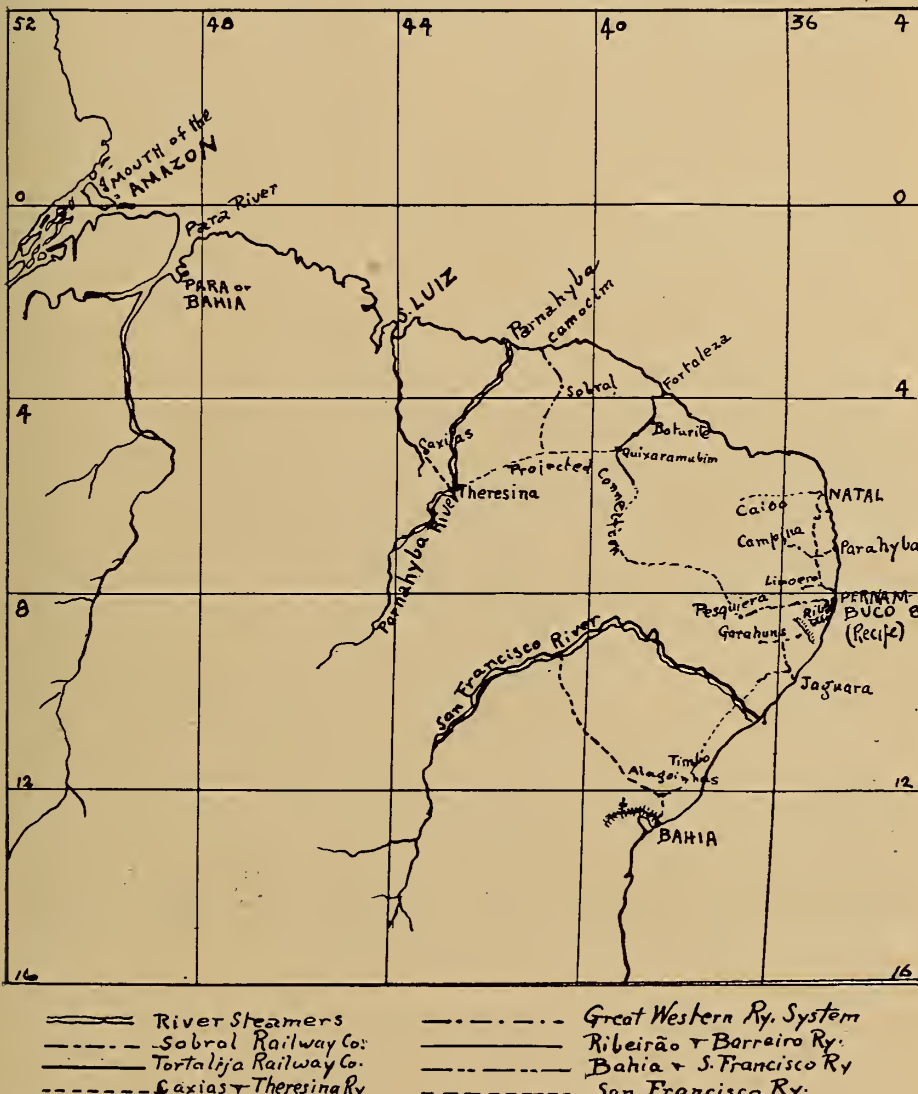
A contract, signed in October, 1890, subsidizes both services, the river part drawing £1,875 (30 contos) for thirty-six trips per

annum. And this number has not been exceeded.

The railway part has a 6 per cent. guarantee of interest on a maximum capital expenditure of £3,012 per mile.

The lines from Praia dá Rainhas upwards will be definitely established only upon completion of the railway.

With the opening of these lines the Amazon watershed will be complete and the second class of lines, the



NORTHERN RAILWAY OF BRAZIL AND PROJECTED CONNECTIONS

The lower part reaches the steamship line, which maintains two steamers plying between Belem and Alcopaça. The *Rio Araguay* is a 126-ton steamer, 107 registered, going 10 knots; the *Itacayuna* a 44-ton boat, 33 registered.

trans-basin ones, should be begun. None of these is in hand or in project, and I wish to point out which, in my opinion, should be the first of these; it is a line from the Upper Guaporé to the Jauru, a tributary of the Paraguay river. The distance,

as the crow flies, is 110 miles. The object of the line is to connect the Amazon basin with Rio de la Plata.

It affords an alternative and much shorter route to Bolivia and Matto Grosso, and would connect them with Paraguay and Argentina, thus reaching the coast either by water all the way down the Rio de la Plata and its tributaries, or by rail from Corumba or Aquidauana to the coast, near Sao Paulo. It has two advantages over the Madeira and Mamoré line; it would be shorter, and therefore cheaper, and whether one went to Buenos Ayres or to Sao Paulo one reaches *somewhere*; whereas in Belem immediate exportation is a necessity.

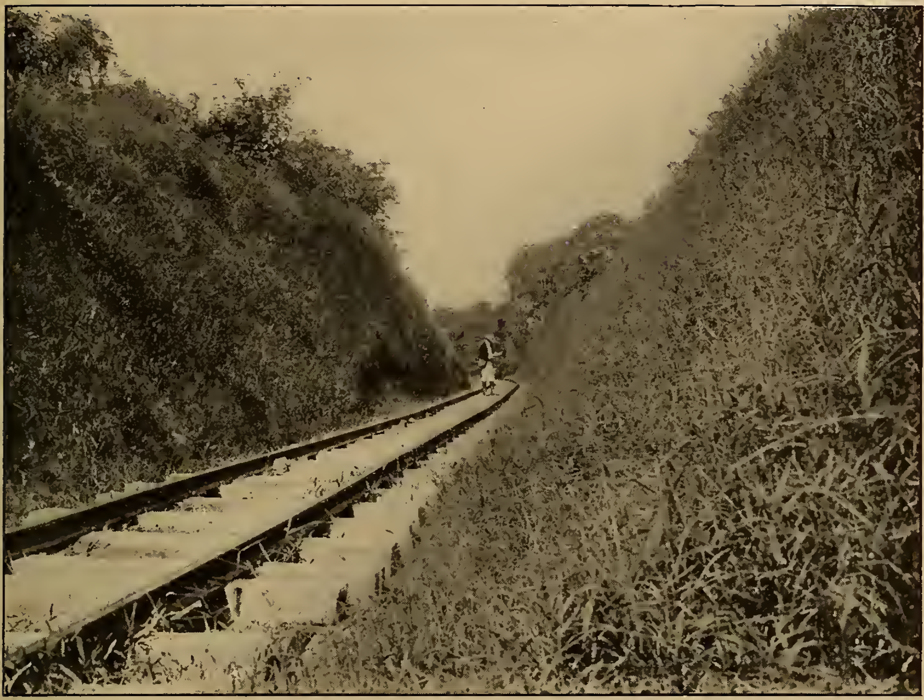
It would be far more difficult to connect the Tocantins with the Sao Francisco or its tributaries, for such a line would have to cross an important range of hills; the Serra de Sao Domingos or the Serra do Duro.

Most of the river traffic of the Amazon and its tributaries is in the hands of an English company, "The Amazon Steam Navigation," whose Brazilian headquarters are in Belem, Para. Its importance can be gauged from the fact that the 1902 contract, still in force, obliges it to cover 235 to 552 miles per annum across a region larger than half of Europe, and also devoid of all other means of communication. From Belem steamers ply to Manaos, 925 miles upstream, to Iquitos, in Peru—2,066 miles of navigation. The length of the other subsidized lines is:

Baiao	105 miles
Mazagao	481 "
Madeira	1,596 "
Purus	2,557 "
Negro	423 "
Oyapock	738 "

The fleet comprises thirty-six steamboats. The *Perseveranca* and

A BUCYRUS STEAM SHOVEL ON THE MADEIRA AND MAMORÉ RAILWAY



CUTTING ON THE MADEIRA AND MAMCRÉ RAILWAY

GIRAU FALLS, FROM WEST BANK OF THE MADEIRA RIVER
The obstruction to transport between Bolivia and the coast.

the *Esperanca* are close upon 1,000-ton steamers (922 tons). They have a speed of 13 knots.

The total tonnage of the fleet is 17,763 and 11,534, registered.

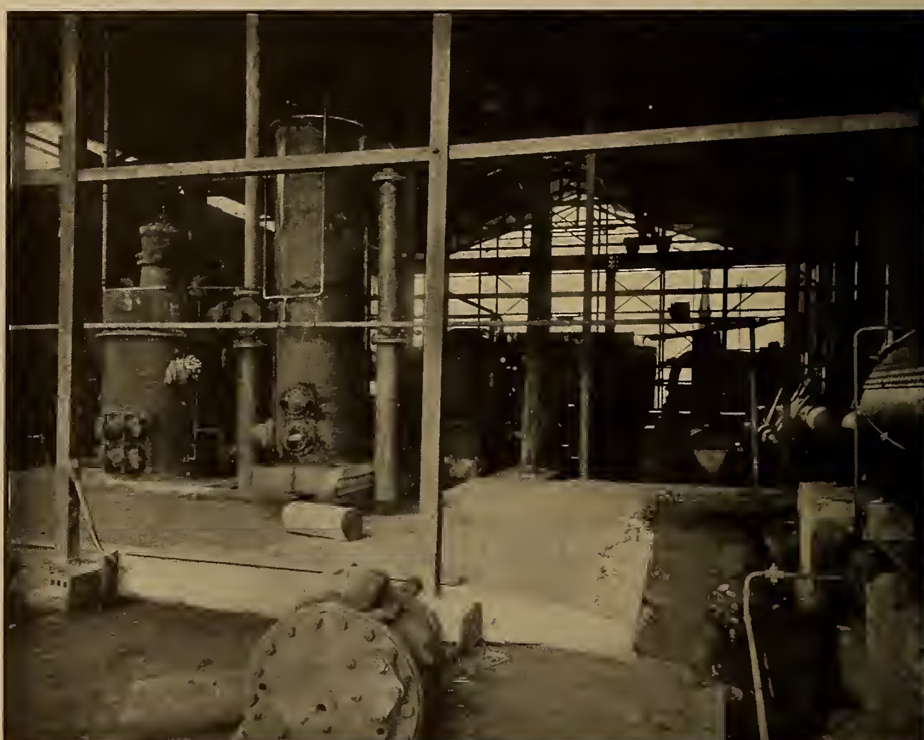
Two classes, as on all Brazilian river steamers, are aboard, first and third; a minimum speed of 10 knots is stipulated in the contract.

The 1907 receipts were £27,804, from the 9,753 passengers, and £63,-192 from the 15,379 tons of goods, besides the annual £25,445 subsidy.

Nearly 4,000 passengers were carried on the Manaos Line, half in each class; 2,000 on the Iquitos Line, 662 first and 1,318 third; on the Baiao Line, 469 first and 483 third; on the Manzagao Line, 451 first and 313 third; on the Rio Purus, 194 and 424; on the Rio Madeira, 386 and 680; on the Rio Oyapock, 147 and 178; on the Rio Negro, 201 and 144 only.

Belem, the company's headquarters, and Manaos, up-stream, are almost seaports, with a traffic rapidly increasing.

In 1905 Manaos was visited by 1,130 vessels; in 1907 by 1,589. Importation consists of 49,000 tons of coal and 75,000 tons of other merchandise, carried by 133 vessels from Europe and America, besides 30,000 tons of goods from Brazil, and 24,-000 tons from up-stream, two-thirds of which are rubber.



INTERIOR OF POWER HOUSE AT PARA, IN COURSE OF CONSTRUCTION

Belem harbour has been considerably improved by the new owners, the Port of Para Company; the works were begun in 1907 and estimated at £6,876,791. But several alterations have increased the cost, particularly the greater depth to which it is dredged, 30 feet and 10 feet, where the river steamers only have access.

There is a short-meter gauge line

THE AVENIDA 16 DE NOVEMBRO, PARA

from Belem to Bragança on the coast. It is 156 miles long, with a 10-mile branch to Pinheiro.

The Rios Itapicuru and Parnahyba, next to the Amazon, are navigable from the coast far inland. Parallel to these rivers the Sobral Railway, from Camucim to Ipu, and the Baturité Railway from Fortaleza, or Ceara, to Quixeramubim, have been built "inwards." All these rail and waterways cease 200 miles, as the crow flies, from the coast, except the Parnahyba river route.

The end of the Itapicuru for navigation purposes is Caxias. This town has been connected by a trans-basin railway of 49 miles, with the nearest port on its neighbour, the Parnahyba river—Therezina. The line ceases on the hither bank at the town of Cajazeiras.

The other lines have no connection inland. A recent government commission, therefore, was appointed, to look into the matter, and decided that the following lines should be built:

From Sao Luiz, on the coast, to Caxias; to provide the town, which already has river connection with the coast, with rail connection as well.

From Therezina to the Sobral extension, a trans-basin line—the most suitable junction seems to be Cratheus. This line has been contracted to the South American Railroad Company in 1909.

From Cratheus to Quixaramubim; to connect the Sobral and Baturité Railway extensions with each other.

A railway from the Baturité extension to the Great Western railway system toward Pesqueira, the present terminal of the Central of Pernambuco. This line, however, will be harder to build, because there is a difficult part to get over or through, the knot of the mountain ranges that form the frontier and that meet near Triumpho.

Taken together, these new lines form a railway having substantially an eastern and western course, with a northerly bend, so as to reach the seacoast in Sao Luiz.

SAO LUIZ, CAXIAS AND THEREZINA.

The Sao Luiz and Caxias line will be 246 miles long, and will be useful to the towns of both Caxias and Therezina, whose railway will become an extension of the new line. The gradients do not rise above one in forty, nor do the curves fall beneath 500 feet radius.

S. S. ENGLAND, LOADED WITH 5,000 TONS OF COAL AND DRAWING 21 FEET OF WATER, AT NEW WHARF, PORTO VELHO

Capital expenditure, including a short branch to Itaqui, is estimated at £1,076,053.

The line will pass on to *terra firma* on a bridge 3,300 feet long; the town of Sao Luiz, of about 50,000 inhabitants, being in a kind of island formed by estuaries of the river.

The Caxias and Cajazeira Railway is leased by the government to the General Company for Maranhao's improvement, with the same guaran-

PAYMASTER'S PARTY ON TRAIL IN THE BRAZILIAN FOREST

tee of interest as is that of the North of Brazil.

The receipts in 1908 were £7,253; expenses reached £8,657; leaving a deficit of £1,404, with a ratio of expenses to gross earnings of 119.35 per cent. The new lines are likely to improve the situation, together with the development of the Sao Luiz Harbour, which is the company's property.

The rolling stock consists of only four locomotives, three coaches and twenty-four wagons.

The Sobral Railway starts from Camocim, on the coast, and runs to Sobral and Ypu, 135 miles.

It was begun by the government in 1878, and was built to give labour to the victims of the terrible droughts that distress that part of the country. Sobral was reached in 1882, and the extension to Ypu was proceeded with the next year.

The line is an easy one. The steepest gradients are one in fifty-five, and the radius of the curves has been limited to 600 feet.

Two short branches will be built soon; one from Granja to Viçosa, the other from Cariré to Sao Benedicto. Their length is 35 and 28 miles respectively.

Since 1898 the line has been leased to Saboia, Albuquerque & Co., and luckily for the government it had been worked at a loss ever since its opening and had cost the government £60,812 in working expenses. Since 1898 the line has continually been worked at a profit, the ratio of expenses to gross earnings being 51.7 per cent. in 1908.

The company owns ten locomotives, all built by the Baldwin Locomotive Works, twelve coaches and fifty-nine goods wagons.

An extension further inland is building, and will be incorporated with the existing line. This extension, from Ypu to Cratheus, is 68 miles long. Its construction was contracted for to the present lessees in 1906 at £2,995 per mile.

The company pays a rent of 4 per cent of the gross earnings, besides an annuity.

The Baturité Railway is the most

CARLOAD OF LOCOMOTIVE DRIVING WHEELS AT PORTO VELHO

eastern of these short penetrating lines. It is 198 miles long to Girau, with two short branches to Alfandega and to Maranguape; together 7 miles.

This railway had been started by a private company; but in 1878, when famine-relief works were most necessary, the government bought back the line. Twenty-five miles of it had been built, and the government continued the construction work.

In 188. the line was opened from Fortaleza to Baturité, 68 miles,

A BAY CITY LOCOMOTIVE-CRANE IN SERVICE AT PORTO VELHO

branches included. It has been slowly continued ever since, reaching Quixada, the 117th mile, in 1891; Quixeramobim, the 147th mile, in 1894, and Senador Pompeu, the 130th mile, in 1900.

The line was hard to build, crossing the Quixaba granite ridge, on the banks of the Satia, an affluent of the Banahuiha river. It then passed between the Urucu and Serra Negra mountains into the wide plain between the Sipo and Cachoeira ranges. It lies nearly entirely in the watershed of the Jaguarhyba, but crosses it diagonally until it reaches its source, where connection with the Great Western Railway is to take place.

This is not the "Baturité" proper, but its extension, which was decided upon in 1906, from Girau to Quixara, a distance of 105 miles. The greater part is already completed and open to traffic. The rails used are

Courtesy of *The World's Work.*

MAP SHOWING THE MANNER IN WHICH THE MADEIRA AND MAMORÉ RAILWAY WILL OPEN UP THE INTERIOR

American, from the Carnegie Steel Company.

The cost of the original 198 miles has been £1,193,639. The line, leased to Messrs. Novis & Porto, is a profitable undertaking. The gross earnings were £77,922 in 1908; expenses, £56,579; leaving a margin of £21,343. The ratio of expenses to gross receipts is, therefore, 72.61 per cent.

The company pays the government a £1,250 annuity, 10 per cent, of the gross earnings, and 20 per cent. of the net earnings.

There was a good deal of bridging to be done; the longest is only 660 feet, with a 210-foot span.

The company owns 137 wagons, 28 coaches and 25 locomotives, all of American make. The latter are typical, and were built by the Baldwin Locomotive Works of Philadelphia.

The specifications of the consolida-

tion and the 10-wheel locomotives are as follows:

These locomotives burn wood exclusively.

DETAILS OF BALDWIN LOCOMOTIVES ON THE BATURITÉ RAILWAY

		Consolidation.	Ten-Wheel Type.
Gauge		Metre	Metre
Class		10.26 E.	10.24 D.
Cylinders	Diameter	16″	15″
	Stroke	20″	18″
Boiler	Diameter	52″	52″
Fire box	Length	83 15/16″	79 7/16″
	Width	27″	27⅜″
	Depth, front	48¼″	49½″
	Depth, back	40¾″	47½″
Tubes	Number	157	147
	Diameter	2″	2″
	Length	11′ 7⅜″	12′ ⅜″
Heating surface	Fire box	87 sq. ft.	86 sq. ft.
	Tubes	948 sq. ft.	937 sq. ft.
	Total	1,035 sq. ft	1,023 sq. ft.
	Grate area	15.5 sq. ft.	15.1 sq. ft.
Wheels	Driver's diameter	37″	42″
	Truck wheels diameter	24¼″	24¾″
Wheelbase	Driving	11′ 9″	10′ 9″
	Rigid	11′ 9″	10′ 9″
	Total	18′ 7″	19′ 10″
Weight	Drivers	65,445 lbs.	54,200 lbs.
	On truck	7,800 lbs.	17,500 lbs.
	Total	72,245 lbs.	71,710 lbs.

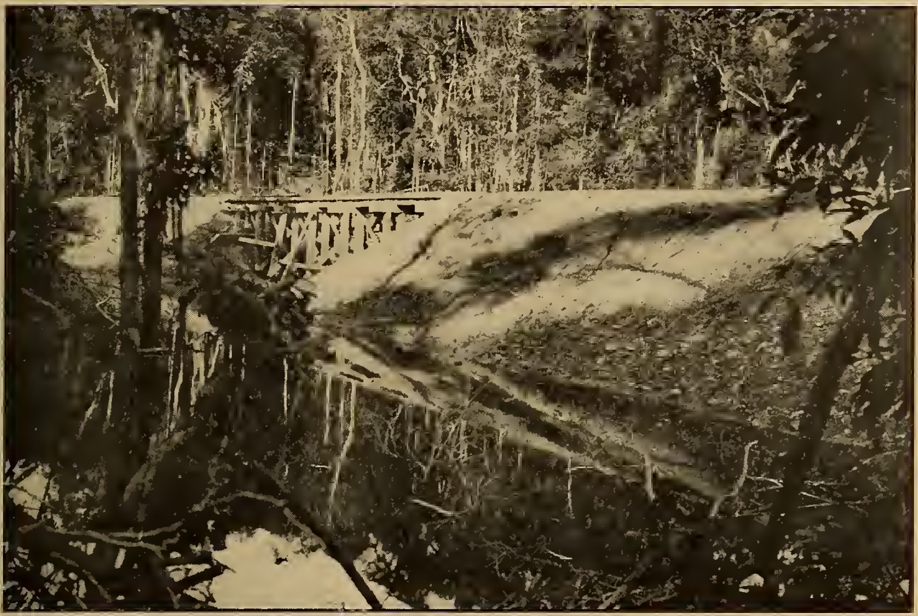
These engines, as usual, in American-built locomotives, have steel boilers and fireboxes and iron tubes. They both have straight boilers, with radial staying, carrying 160 pounds pressure. The sheets are half an inch thick.

The water-space dimensions are 3½ inches in front, 2½ inches at the sides, and 2½ inches at the back.

The tenders are carried on two four-wheel trucks, with 28-inch wheel. The tank capacity is 1,800 gallons, and the fuel capacity two cords of wood.

Both the Baturité and the Sobral railways, started as relief lines, have a fine future before them; the more so as, owing to the help of the States they serve, both lines are rapidly improving.

CONSTRUCTION WORK ON THE MADEIRA AND MAMORÉ RAILWAY

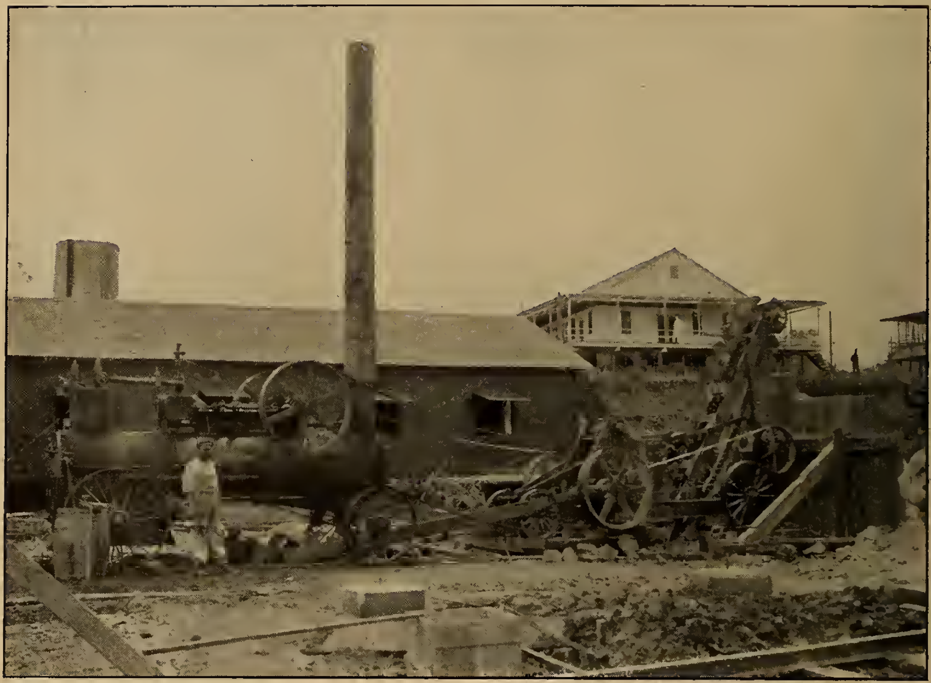


A BRIDGE ON THE MADEIRA AND MAMORÉ RAILWAY

The Parnahyba Steam Navigation Company has been subsidized by the government. The Parnahyba river is a most important line of communication, stretching, as it does, to the very depth of the State of Piauhy. Two steamer lines start from Therezina: the one up-stream to Floriano, the other down to the river mouth at Parnahyba Town.

The company's eight steamers covered 18,120 miles in 1907, carry-

TEMPORARY BRIDGE ACROSS JACY-PARANA, LOOKING NORTH



STONE-CRUSHER AND ENGINE, ALSO CONTRACTOR'S OFFICE, PORTO VELHO

ing 1,975 passengers and 2,298 tons of goods.

The receipts were £19,874.

The 1907 contract fixed the subsidy at £6,000, and the monthly trips at four; down-stream, two, up river, and an extra trip along the coast westward to Tutoya in con-

PORTO VELHO, LOOKING NORTH FROM RIVER-BANK, SHOWING IGARAPE DE CANDELARIA, WHARF, SAWMILL, OIL PLANT, AND S. S. ENGLAND

PORTO VELHO. DERANGEMENT OF PILING OF HIGH-WATER WHARF, CAUSED BY SLIDES IN RIVER-BANK

nection with the steamer of the Brazilian Lloyd Company.

Such is the present state of the northern rail-and-river system; only an embryo as yet if one considers the enormous tract of country it is called upon to serve, but already an important one, considering the energy expended in creating it. Still, an enormous amount is to be done, and new lines are being pushed vigorously; that is why this region, of all others, has such splendid openings for capital and enterprise.

PORTO VELHO. HAULING BOILERS TO POWER HOUSE, AND MARCONI WIRELESS TELEGRAPH STATION

THE ELECTRIC DRIVING OF COTTON-PICKING MACHINERY

By Albert Walton

AFTER the cotton bale has been opened by the hand-cutting of the steel bands which were put on in the compress it is found to consist of rough layers of a more or less compact nature, their long confinement under pressure having wadded them into a tough mass. Bits of leaves and particles of seeds and husks are present, together with a certain amount of sand and grit. Before the cotton can be carded, drawn and spun its fibres must be separated from one another and from this grit and other foreign matter. The knotty tufts must be opened out and the whole brought to a clean and fluffy condition. To do this, important but rough-work "picking" machinery is provided in all cotton mills. These are the coarsest and most massive machines in the entire mill and, through long experience, have become well standardized, the usually accepted sequence being as follows, though some variations in the processes exist to accomplish certain ends in mills whose product is out of the ordinary:

1. Bale breaker, or hopper bale opener.
2. Opener.
3. Breaker.
4. Intermediate.
5. Finisher.

The opener and breaker are quite frequently combined as one machine, but not always. The functions of these various machines are all very similar. The bale opener breaks the compact layers up into tufts, still more or less compact, which are further broken up in the opener, where also the first cleaning action takes place. A suction fan in the breaker draws the fleece from the opener in a continuous stream through a broad, flat flue or "trunk," the rate of motion being slow enough to allow much of the heavier dust to settle into slots or pockets, while the cotton passes forward. The breaker repeats the process of the opener, further opening the tufts and separating the fibres, while, at the same time, cleaning them. Both of these machines make use of rapidly revolving beaters in an iron cage. The bottom of the cage is a grid, which allows the dirt to be driven through, while too finely spaced to permit the tangled fibres to pass. The cotton is fed to the beater in a rough blanket, about 40 inches wide. This is broken up by the beater blades and drawn from the cage by a second suction fan, formed into a sheet and rolled up about an iron mandrel. This roll is called a "lap" and any of the machines which form such rolls are called "lappers."

Inasmuch as one of these laps will eventually be drawn out and spun into many miles of fine yarn, it is desirable to secure, even at this early stage, great cleanliness and uniformity. With this end in view four of these laps are now fed simultaneously to a third machine, called an intermediate. This quadruple sheet is again beaten apart and again spread out and wound up as a cleaner and more uniform lap. With the thoroughness characteristic of a cotton mill this process is again repeated by feeding four of the laps from this intermediate into a similarly constructed machine, called a finisher. The lap formed on the

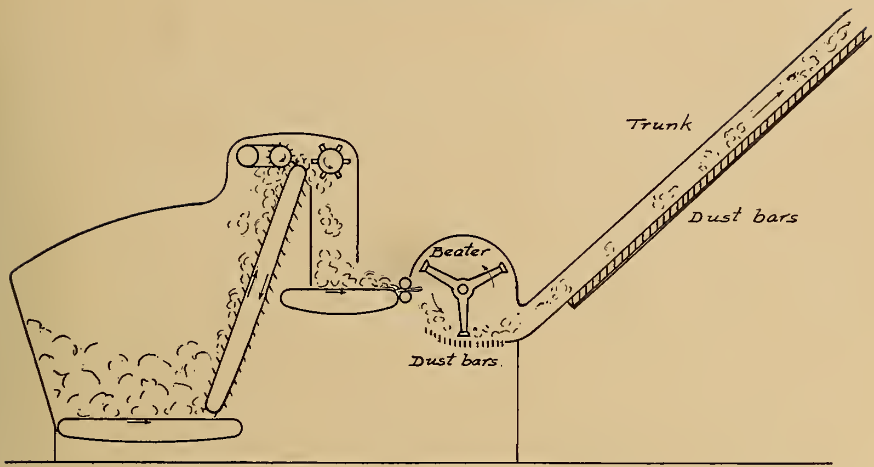


FIG. 1.—DIAGRAM SHOWING ARRANGEMENT OF ESSENTIAL PARTS OF AN OPENER PICKER WITH INCLINED TRUNK TO BREAKER ON THE FLOOR ABOVE

finisher is about 40 inches wide and 16 inches in diameter, contains about 50 yards of loosely laid cotton, about half an inch thick, and weighs within very close limits about 45 pounds. A variation in weight of over 1 per cent. from a fixed figure is enough to throw the lap out and necessitate its passing through the finisher a second time.

With this machine the rough unifying and cleaning process is completed and the finer work begins, the lap passing on from here to the cards and other machines of the later processes. With this explanation and the diagrammatic sketches, what follows may be more readily comprehended by those unfamiliar with the machines themselves.

ESTABLISHED METHODS OF DRIVING PICKERS.

For half a century pickers have been driven in the same fashion. A long belt from the line shaft passes to tight and loose pulleys on a countershaft, which is part of the machine itself and upon which is carried the large driving pulley, which belts to the small pulley on the beater. This high-speed countershaft is a necessity, since the line shaft runs at a relatively low speed, while the beater requires from 1,100 to 1,500 revolutions per minute. The countershaft usually runs about 500 revolutions per minute, and, in addition to serving as a means of speed multiplication, serves as the point of control, the machine being stopped and started by the motion of a small handle on the side of the superstructure operating a shipper fork, which controls the position of the belt on tight or loose pulley.

The picker is normally started but twice a day—morning and noon—its operation being practically continuous from then till shut down for noon or night. In the first two stages of the process (opener and breaker), the action is entirely continuous except for accidental clogging of the cotton. In the last two (intermediate and finisher) the desirability of producing laps of a uniform weight has made necessary the provision of an automatic device for stopping the "feed" after a certain number of revolutions have been made by the rolls forming the lap. This occurs about every 8 minutes, but at this time the main belt is not shifted and the counter, beater and fans, comprising half the working load, continue to revolve. In some mills this is a source of waste

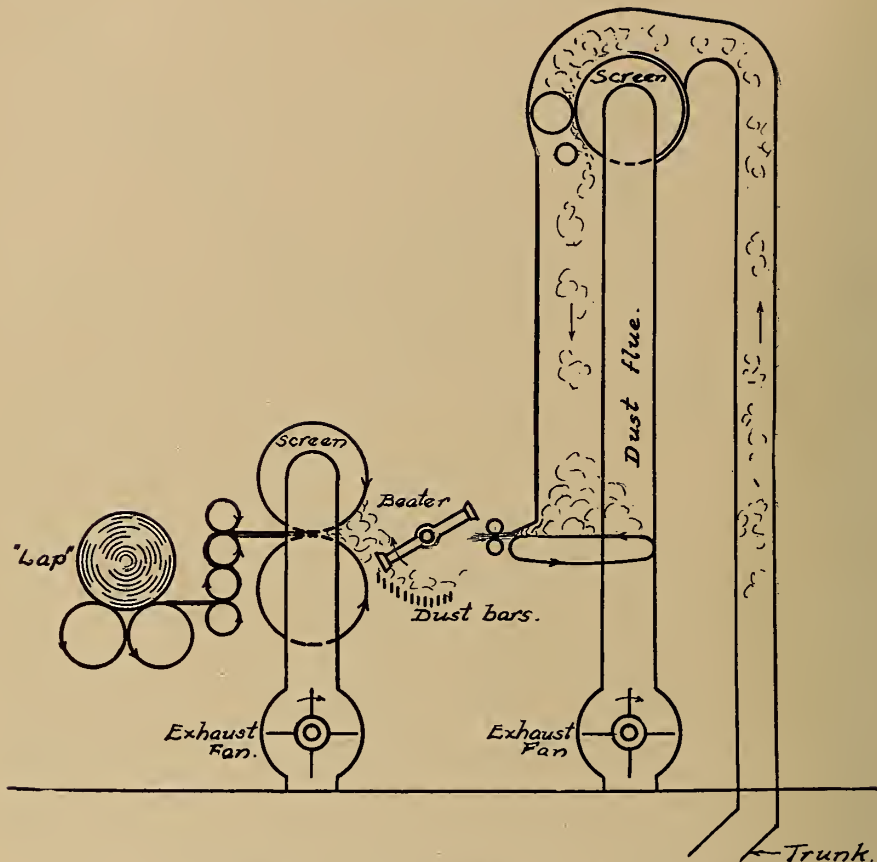


FIG. 2.—DIAGRAM OF ESSENTIAL PARTS OF BREAKER-PICKER RECEIVING COTTON THROUGH TRUNK FROM OPENER

of power, but in as many the work is so nicely timed that the completed lap is removed and the feed started for a new lap in a very few seconds after the automatic stop motion has acted.

DISADVANTAGES OF PRESENT METHOD

The disadvantages of the present drive are four-fold. It has an element of danger, is inefficient and lacking in neatness, and puts the machine under undue operating strains.

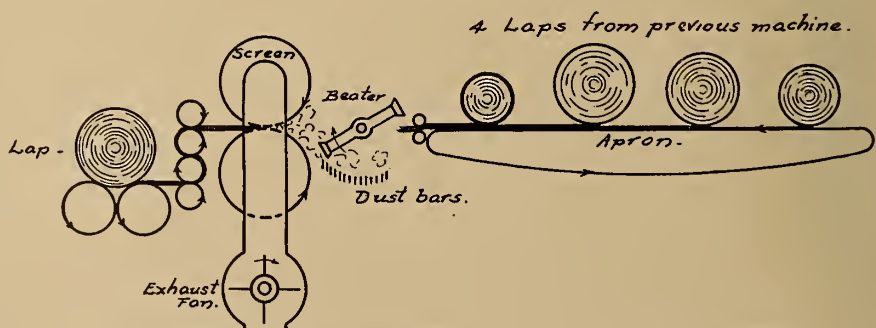


FIG. 3.—DIAGRAM OF INTERMEDIATE AND FINISHER PICKER

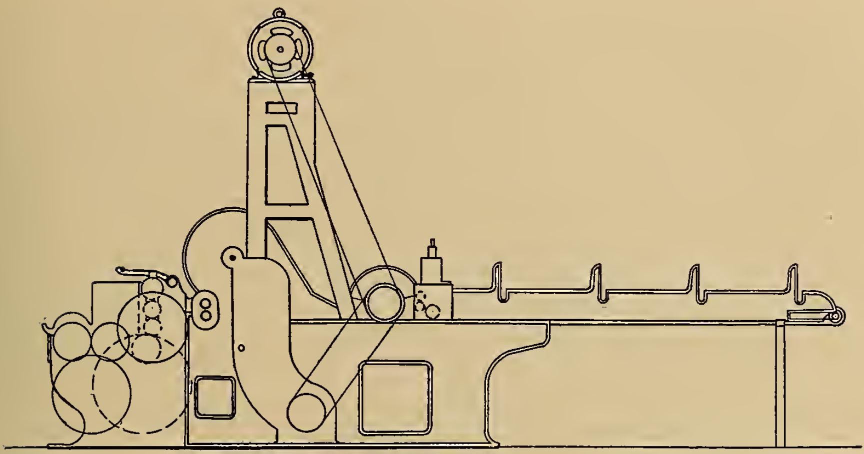


FIG. 4.—WESTINGHOUSE NO. 4 B. T. TEXTILE TYPE MOTOR AND KITSON ONE-BEATER FINISHER

It is a source of danger, because the high-speed belt, from counter to beater, runs over an unguarded pulley at about the level of the operative's hands and between him and parts of the machine which must be handled. It is inefficient primarily because the picker room is a bad place for a belt drive, and secondarily, because this drive in particular is a bad one. Every belt in a picker room has to be "carded" or cleaned of its accumulation of lint very frequently. On the belts from line shaft to line shaft and from line to counter this is both bothersome and risky, while on the belt from counter to beater it is frequently dangerous. Yet before the cleaning time has come around again the belts are lined with lint and are again liable to be slipping badly. To reduce this slippage excessive tensions are used, causing undue wear on all parts so driven. This is of importance on the beater bearings not alone because of the cost of replacement but because of the resulting change in the adustment of the distance from the heater blades to the nip between the rolls, thus affecting the work done by the picker.

Not only does the lint collect on the belts and pulleys, however; the air is full of it and large quantities settle on the countershaft superstructure and the overhead shafting and hangers, the belts carrying it from point to point. It drains the oil reservoirs and clogs the boxes, and for successful operation should be cleaned off at least once a day and sometimes more frequently. This necessitates clambering over the machines after quitting-time and is an item in picker-room maintenance that might well be dispensed with.

Power is used to no advantage when belts slip, but even where no slippage is occurring this system consumes quantities of power in its tight belts and high-speed shafts, amounting in the best of installations to 25 per cent. of the total power delivered to the room. Of prime importance, however, to the mill man is the item of production. It is a very rare case indeed in which the beater shafts will be found to be at the speed they are designed to run. The importance of this is understood when it is realized that the feeding parts and the lap rolls are driven directly from this beater shaft, thus being affected directly by any change in speed of this part, a falling off meaning a proportional loss in production of the machine. In one well-known mill in America the following speed readings were

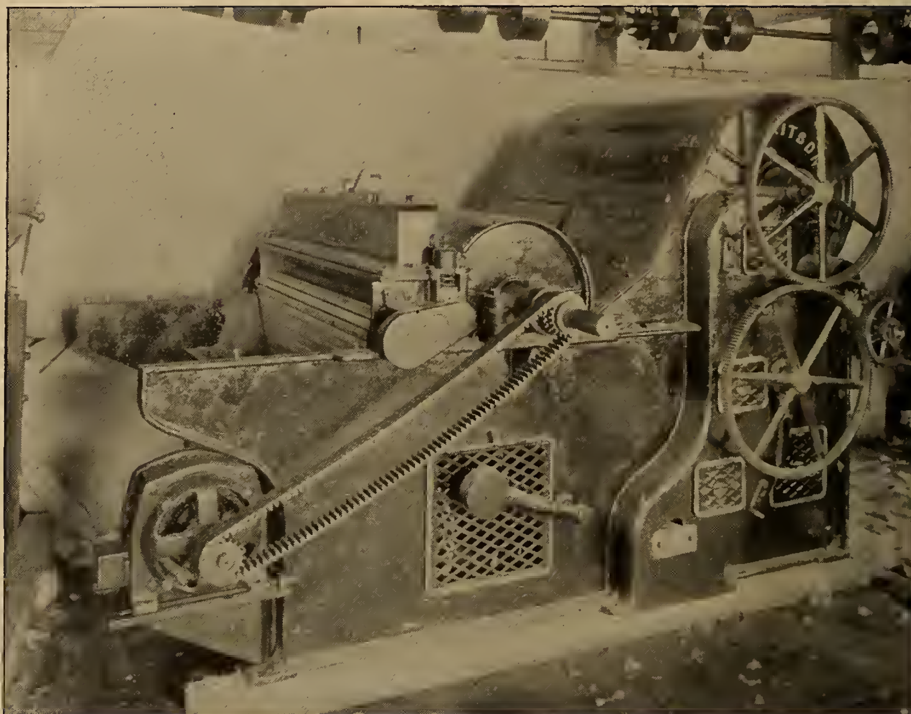


FIG. 5.—SECTION OF A FINISHER PICKER IN COURSE OF ERECTION, WITH GENERAL ELECTRIC MOTOR DRIVING A KITSON PICKER WITH MORSE SILENT CHAIN

actually taken on beater shafts said to be running at 1,300 revolutions per minute:

	1,212	1,095
	1,198	1,185
	1,196	1,193
	1,180	1,202
	1,202	1,190
	1,115	1,087
	1,080	1,102
	1,140	1,196
	1,192	1,188
Average	1,172	1,160

In this case five belts intervened between the source of power, a pair of large water-wheels, and the beater shafts. Since this includes the two belts on the picker, it will be seen that the drive was very direct and that in the average mill this number of belts will generally be found exceeded rather than reduced.

GROUP DRIVE WITH ELECTRIC MOTORS

Only a slight amelioration of these conditions was effected when the electric motor was belted to the line shaft of the picker room, since the objectionable elements still remain. However, this was a step in the right direction. The picker room is always capable of supplying more cotton than the mill needs, so it usually works an eight or nine hour day, while the mill is running one or two hours more. The electric drive permitted the stopping of this section independently of the rest of the mill, so that cleaning-up could be finished by the usual quitting time, as well as effecting a saving in friction losses.

With this system we still have all the belts and speed fluctuations of the direct-engine drive, and all its other drawbacks. The introduction of electricity into the room has, however, made possible the use of the

individual motor, which, as we will show, can be made to eliminate, at once, all the undesirable features of the old-fashioned drive. In addition to this it introduces two entirely new items into picker driving, which are attracting much attention and interest. The drive in all of its applications is a simple one, yet one that has required not a little experimentation to perfect. There are three different methods of applying the motor to its work, no one of which best fits all cases, any one of them being used as occasion demands only after a thorough investigation by a capable engineer. The motor may be placed on the ceiling above the picker and connected by belt to the beater shaft without intermediate reduction, or it may be mounted on a bracket on the picker side and drive through a silent chain or, again, it may be placed directly upon the beater shaft without any transmission device whatever. Each drive has its distinct peculiarities, the advantages of which we will discuss separately.

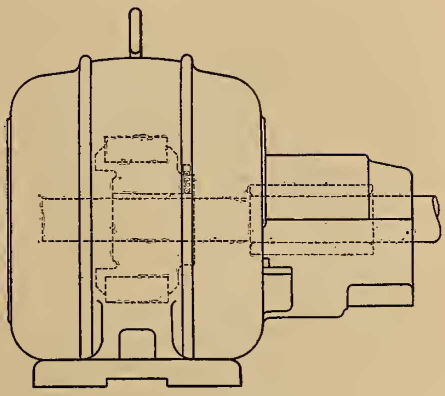


FIG. 6.—SPECIAL WESTINGHOUSE PICKER MOTOR WITH PICKER BEARING AN INTEGRAL PART OF MOTOR

BELT DRIVE FROM INDIVIDUAL MOTOR

While mounting the motor on the ceiling and belting down to the beater shaft has much to recommend it, it still retains one of the uncertain elements of the old drive—the lint-covered leather belt. A comparison of the two drives will quickly show, however, that the change is greater than this bare statement would imply, for, while all belts in a picker room are subject to slippage from lint, the conditions under which the belt to the beater shaft runs are greatly improved. The old drive was nearly vertical and the distance between pulley centers was less than six feet, in addition to which the ratio of pulley diameters was about three to one, making, all in all, one of the most unsatisfactory belt drives imaginable. With the substitution of the motor for the counter we get a 12-foot drive which can be arranged at an angle from the vertical, the pulley ratio being nearly one to one. Thus, while a lint-covered belt is still retained, belt-wrap is greatly improved, excessive belt tension is thereby avoided, and a more practical angle of belt inclination made possible. The costly and objectionable countershaft superstructure is eliminated and with it go all the overhead belting and shafting in the room. The motor being located on the ceiling is both an advantage and a drawback. It is out of the worst dust, yet is, by the same token, out of reach for inspection and cleaning. Similarly, while the belt is a source of slippage and loss of production, and carries lint up to the motor, it also provides a certain flexibility of transmission which may be deemed very desirable in certain cases. Where pickers are liable to choking or clogging a certain degree of protection to the feed gears is accorded just as with the old drive by the tendency of the belt to slip and on severe stoppages to run off the pulley entirely. This can, however, be taken care of more satisfactorily by circuit breakers in the motor wiring, as will be explained later. Nevertheless, after all is said and done, the belt remains with this system an element of weakness and danger, and this is true whether the motor be

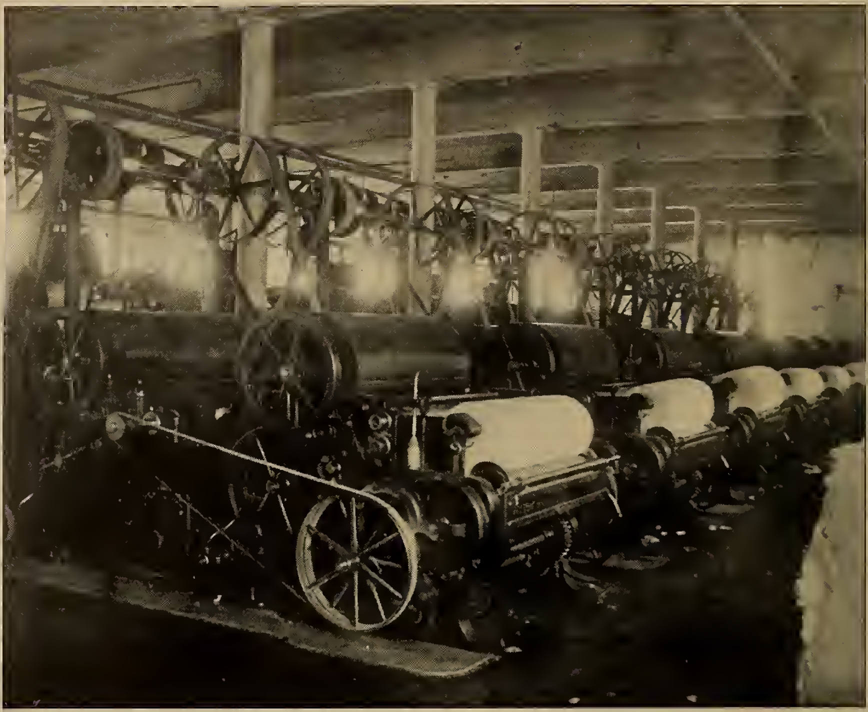


FIG. 7.—A PICKER ROOM DRIVEN BY THE OLD SYSTEM WITH BELTS AND SHAFTING

placed on the ceiling or on a stand similar to the countershaft stand, as has been done in some cases. Only half the step has been taken and not all the possibilities of the individual drive have been realized. To gain the full advantage of the change the even rotative speed of the motor should be transmitted to the beater without chance of slippage. To accomplish this, three possibilities present themselves—gears, chain and direct connection. Gears, so far as we know, have never been tried, and it seems unlikely that they would operate successfully, owing to the high speeds of rotation. Both of the other methods have been tried and are in operation at the present time.

CHAIN DRIVE

For such machines as cannot be driven by direct connection, owing to considerations of speed, a silent power chain forms a convenient method of transmitting the power without possibility of slip or loss of production. The motor is placed on a bracket on the side of the picker, either on a level with the beater shaft and in front of it, or back of the shaft and down under the apron or corresponding part of the machine. In this drive we have the motor at a convenient level for inspection and oiling, but also in a very dusty location. With present "textile-type" motors this latter consideration is of little importance, since the construction is dustproof throughout and needs little cleaning. The chain can be enclosed and danger from this source eliminated. A circuit breaker is placed in the motor circuit when clogging is of sufficiently common occurrence to warrant it. The clogging puts a heavy load upon the motor, which instantly draws a heavy current from the line tripping the automatic circuit breaker and cutting off the power. The motor at once comes to rest and all strain is avoided. Thus, while the drive is unyielding and permits no slip, the

strain beyond which it is desired not to go can be predetermined and the device arranged to cut out at that point.

We are now certain of our picker speed remaining at the desired maximum, have eliminated all the overhead work in the room and the cleaning incident to its maintenance and have obviated the liability to breakage, due to choking of the cotton, but we still have a transmission element, the elimination of which is a step still further in advance.

DIRECT CONNECTION

Desirable as is direct connection, it is not possible to accomplish the best results by its application in all cases. The method is the acme of simplicity and efficiency. The superstructure is removed, as in the previous cases, and the eight or ten-inch pulley taken from the beater shaft. This leaves one end of this shaft clear, with the exception of a small pulley, which drives the fan near the bottom of the picker. This fan drive is transferred to the other side of the picker by removing the fan shaft and replacing it "end for end," this being easy of accomplishment, since the fan is held on the shaft only by set screws. With the driving pulley for this fan now on the other end of the beater shaft we have one end entirely free of pulleys and extending 10 inches beyond the end of the large bearing housing whose outer end is itself some 6 or 7 inches beyond the straight side of the frame. There is thus plenty of room to place a motor armature on this shaft extension and to so mount the stationary "fields," or primary, that the armature will revolve freely within it. The shaft is rigid in the extreme, being not less than 2⅛ inches in diameter, and no bearings are required on the motor itself. The motor frame, resting securely on a cast iron bracket bolted to the picker side, touches the armature or shaft at no place, merely surrounding it and causing it to revolve in its accustomed place and with the usual clearance between stator and rotor. Although this

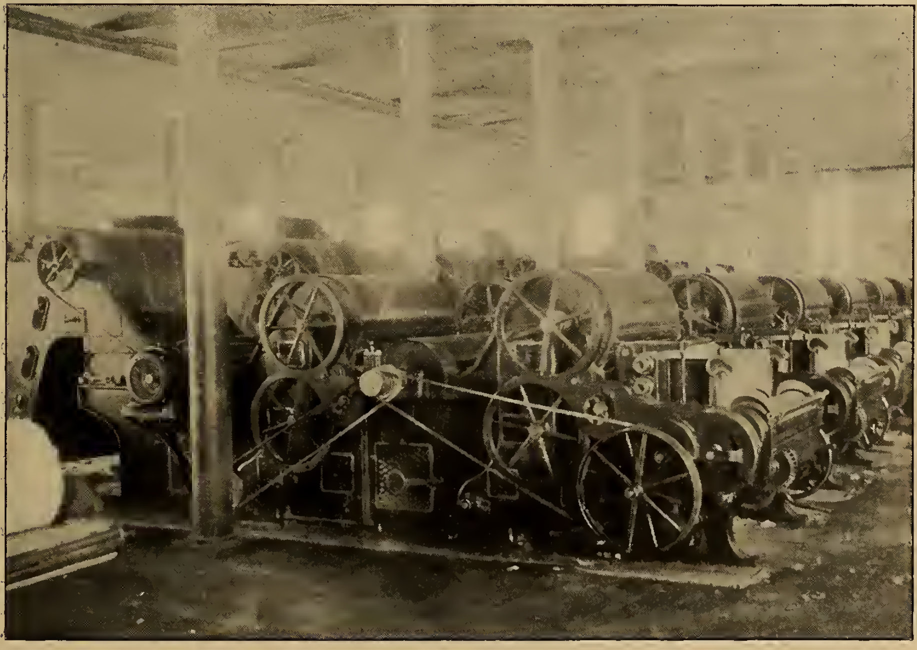


FIG. 8.—THE SAME ROOM AS SHOWN IN FIG. 7, AFTER THE INSTALLATION OF INDIVIDUAL MOTORS

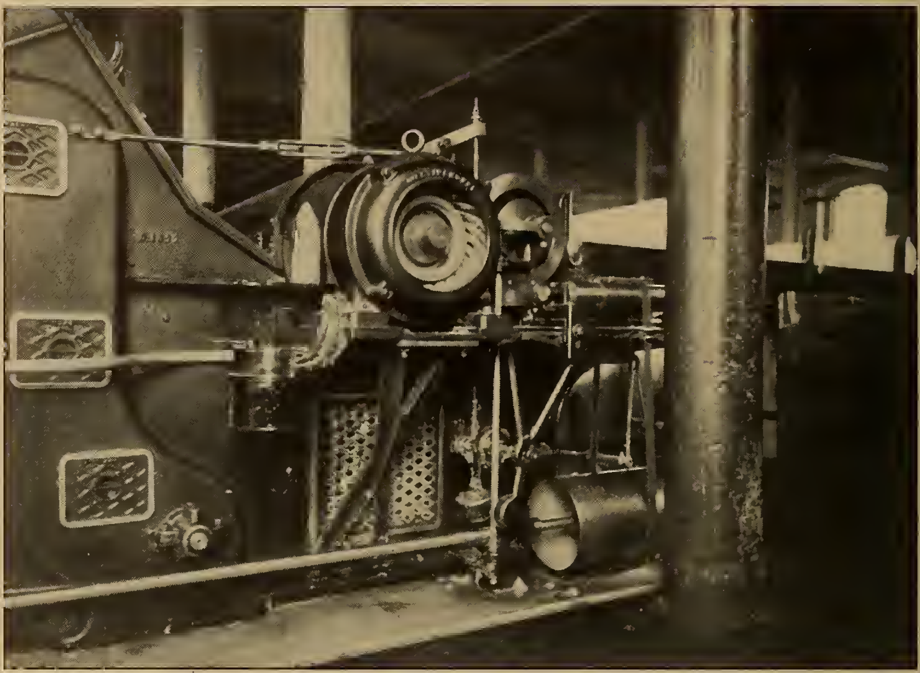


FIG. 9.—DETAIL OF WESTINGHOUSE PICKER MOTOR, SHOWING ROTOR ON BEATER SHAFT

clearance is relatively small, it is sufficient, because the beater shaft is held in a perfectly central position by two heavy bearings more than 40 inches apart, and because considerations of mechanical strength have made it necessary to use so liberal a shaft with the old belt drives. It is not only not necessary to cut or alter the beater shaft in any way, but it is not desirable to do so, since it is frequently necessary to reverse the beater shaft end for end in its bearings, so as to bring into play the reverse edges of the blades. When both edges of the beater are dulled by service it is removed and sharpened. The motor must be so arranged that it can be easily removed, just as the pulley was formerly taken off, and the shaft must be left of standard diameters, so pulleys and motor are interchangeable and can be placed on either end.

For this drive an automatic circuit breaker is used if the work demands its installation. If choking of the beater or calender is a remote possibility, an ordinary oil-immersed textile type switch is used. If the cycle of operations is such that the lap may be completed while the attendant is busy elsewhere, and the machine thereby be allowed to run idle from time to time for any considerable period, the switch or circuit breaker can be attached to the same lever by which the feed is automatically disconnected, so that the power may also be cut off, thus affecting a saving in this direction. Usually the work is so arranged that the operator is at hand upon the completion of each lap to remove it instantly and start the feed for another.

Unfortunately it is not possible to design polyphase alternating-current motors to run at all speeds. The nature of the motor confines the designer to certain fixed speeds and these are, in the usual American plant, 1,750, or 1,150 revolutions per minute for 60 cycles, or the latter for 40 cycle plants. Much divergence of opinion exists as to the best speed at which to run beaters,

but without radical change of design it seems to be conceded that 1,750 revolutions are too fast for good results, although direct connection to a motor of this speed was, we understand, attempted by an over-enthusiastic advocate of the drive. On the other hand, common practice with belts seems to indicate a speed somewhere between 1,350 and 1,500 revolutions on the last two machines of the picker room, and from 800 to 1,200 on the others, with a large majority running near the latter figure. However, in many cases there is no good reason to suppose that 1,150 turns will not produce as good results as the higher speeds, which have been maintained largely as an unquestioned matter of habit. It has been found on certain staples and grades that a slower speed is an advantage, and, in other instances, that at the lower speeds no difference in the cleaning and beating was perceptible, the rate of feed in pounds per minute being maintained the same. As a result, two very large and well-known mills in New England have just installed this method of drive on a total of 175 pickers, on practically all of which the beaters were running from 1,300 to 1,400 revolutions per minute. In both of these mills complete belt and shafting drive has been thrown out and first cost has not entered the problem in either case. In one mill the drive replaces engine drive, and the predominating consideration was one of speed, the slippage in transmission having proved excessive and very erratic. In the second the determining factor was one of power economy and general efficiency, the direct drive replacing a belt drive from two 150-horse-power motors and showing a power saving that will pay for the change in about four years, not counting the credit items of the two motors and the scrap value of belts, shafting and machine parts.

FIG. 10.—A LARGE PICKER ROOM DRIVEN BY DIRECT-CONNECTED MOTORS

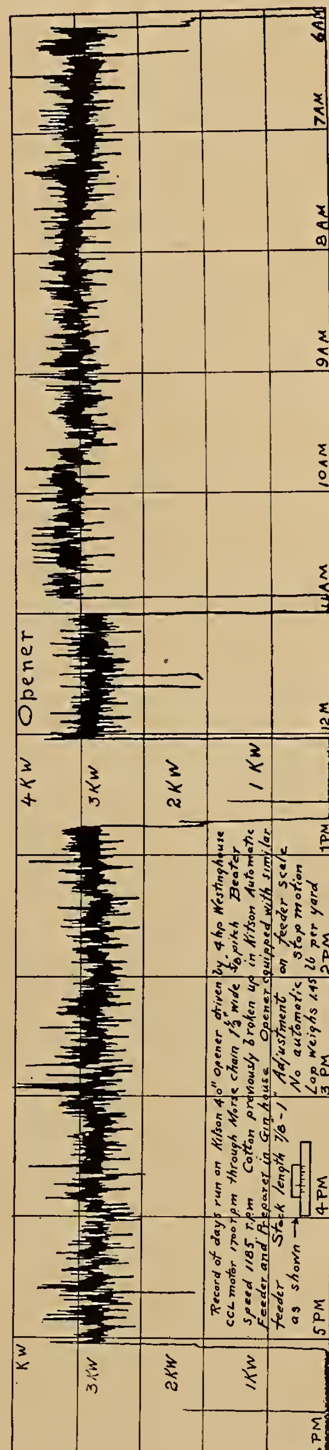
The broad experience gained in equipping these mills and the success met with have induced the electric

FIG. 11.—VIEW OF PICKER ROOM WITH BELT DRIVE, SHOWING MASS OF OVERHEAD WORK OBSTRUCTING LIGHT FROM WINDOWS

FIG. 12.—VIEW OF ABOVE PICKER ROOM AFTER INSTALLATION OF INDIVIDUAL ELECTRIC DRIVE

companies to perfect a motor for this class of work. The essential parts of the "picker motor" are the same as the standard textile-type motors, but it was found that the task of aligning the stator of the motor with the rotor was rather a painstaking one, although once in the proper position it required little attention and no realigning for many months. Nevertheless, to eliminate this feature and to secure a more perfect bearing than is used on the usual picker, the new motor is provided with a special end-bracket with a large babbitted, ring-oiling, dustproof bearing incorporated rigidly as part of the motor frame. This replaces the picker bearing and is bolted on through the same holes as were previously used. The motor rests on an adjustable stand, shown in the photographs, and the bearing is supported on the usual shelf provided for the picker bearing. Thus the alignment of stator and rotor is fixed and permanent, and the installation becomes a very simple matter. The bearing is made to fit any of the standard makes of pickers and will be used in all future installations.

The direct-connected drive is so eminently desirable that it is expected that it will be applied more generally as time goes on. In conversation recently with the "road man" of one of the leading manufacturers of pickers the writer was informed that the tendency, both North and South, is very markedly toward lower speeds on the beaters, 1,000 turns being now much more common than it was five years ago, and 1,400 turns correspondingly more rare. It is found that the higher speeds damage the fibres without effecting any greater cleaning. It is possible to beat the cotton so fast that the dust has time to fall through the slots, but is carried on with the fibres to the screens and lap rolls. This tendency toward lower speeds will greatly accelerate the adoption of the direct drive with motors of 1,150 revolutions per minute.



POWER RECORD OF KITSON BREAKER WITH AUTOMATIC FEEDER DRIVEN BY WESTINGHOUSE MOTOR

One interesting feature of the development of the individual drive for picking machinery has been the affording of an opportunity to secure what it pleases our fancy to designate as "inside information," by which we mean reliable data as to what is going on within the machine. This is an item previously impossible to get at. It cannot be secured from a group of machines because the averaging effect of this method hides the individual characteristics of each machine. A power scale is too uncertain and even the usual indicating wattmeter, with a test motor, gives only an inkling of the fluctuations. The accompanying curves were drawn by a Westinghouse graphic recording wattmeter and show accurately, and in detail, the power of three stages of the picking process, the breaker with automatic feeder, the intermediate and the finisher.

DISCUSSION OF CURVES.

The breaker curve records the power history of a Westinghouse 5-horse-power motor driving through a Morse silent chain to the beater shaft of a 40-inch Kitson breaker lapper with automatic feeder and preparer. It is a machine with one three-bladed beater, with one fan and one cage section, and a lap-head for a 40-inch lap. The automatic "stop-motion" was disconnected, the feeding being uninterrupted and the lap being allowed to roll up until removed by the attendant.

The chart represents the run of an entire day, the heavy vertical lines denoting the hours as marked at the bottom, the fine horizontal lines showing the scale of power taken by the motor. It will be noted that the motor was started about 6.07 A. M., and that for about three minutes the power required was only about 1.8 kilowatts while the motor was running only the fan and the beater. When the feed was started and the beater began to break up the cotton the power rose to about 3 kilowatts. Immediately an irregular fluctuation set in, due to the irregularity in the amount of cotton fed to the beater and the toughness of the masses. The feed was shut off for an instant at 6.20, but was quickly started again. It then ran continuously until 10.42, when the motor was stopped for eight minutes to make adjustments. The feed was stopped twice between 11 and noon. At 12.42 the motor was again started and the feed thrown on at 12.45. In the afternoon the feed was stopped three times, but the motor ran until 5.03 P. M., when it was shut down for the day.

It is noticeable that at more or less regular intervals the power is reduced below the average, as shown by the lines projecting below the broad band of the record. This was caused by the removal of the lap, when the attendant judged it was large enough to be taken off. To do this the pressure under which the lap is being wound is momentarily released. The mandrel on which the new lap is to be wound is then placed on the outcoming sheet of cotton and the pressure again applied while the new lap is forming. The feed is not stopped to do this.

At 6.15, 7.20, 2.50 and 4.35 the cotton came through in compact masses for a short interval and caused the power required to increase correspondingly.

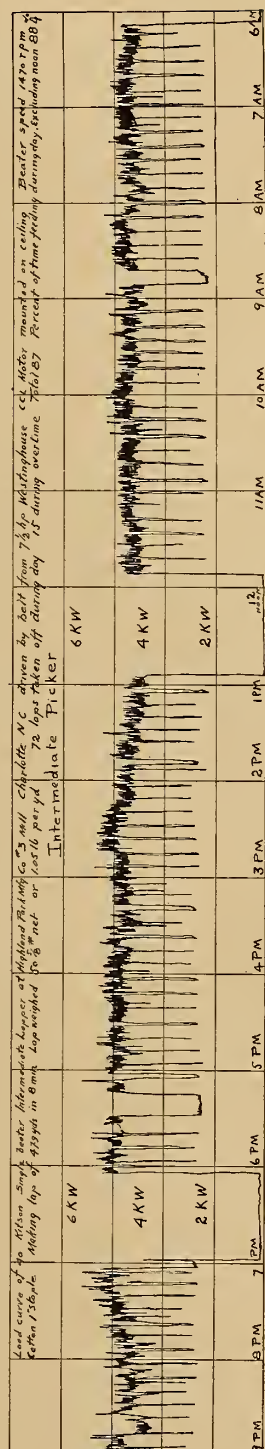
The intermediate picker record is the power history of a 7.5-horse-power Westinghouse CCL motor, driving through a belt from the pulley of a motor on the ceiling to the pulley on the beater shaft of a 40-inch Kitson intermediate lapper. It is a one-beater machine, the beater being a two-bladed one, and there is but one exhaust fan belting from the beater shaft, and one cage section and a lap head for a 40-inch lap. The automatic stop motion was used and operated at eight-minute intervals, winding a lap 48 yards long, weighing 50.6 pounds. The beater speed was 1,470 revolutions per minute. The machine was supplied

with an evener, a cone pulley and sliding-belt device operated by a row of broad fingers pressing on the sheet of cotton as it passes into the beater box and designed to proportion the rate of feed inversely to the thickness of the sheet being fed, so as to make constant the quantity of cotton per unit of time.

The record shows that the motor and picker were started at 6.09 A. M., and that in eight minutes a 48-yard lap was completed and the stop motion cut off the feed automatically. The attendant was waiting, however, and removed the lap at once and immediately started the feed, so that the machine was running idle but a few seconds. A little after 7 A. M., it will be noticed, the power curve becomes more erratic, and at 7.15 and 7.25 the feed was shut off for three or four minutes instead of as many seconds. This was because the evener belt was slipping, causing uneven thickness of cotton to pass to the beater with a corresponding reduction in speed. The heavier the masses the beater has to break up the more power required. The longer stops between laps were necessitated by the time consumed in trying to adjust matters. The trouble, however, continued throughout the day in spite of several attempts to fix it, as indicated by the raggedness of the curve and by the long stops at 8.45 and 5.15, and the shorter periods at more frequent intervals.

The curve shows that, owing to a press of orders, the mill was run overtime the day of this test, and a third session of from 7 to 9.15 added to the already long day. By this record it is possible to count the number of laps rolled up and the percent of total working time the machine was operating. It shows that seventy-two laps were formed in the two regular sessions and fifteen at night, and that the picker was working 88.4 per cent. of the time the motor was running.

The power record of the finisher

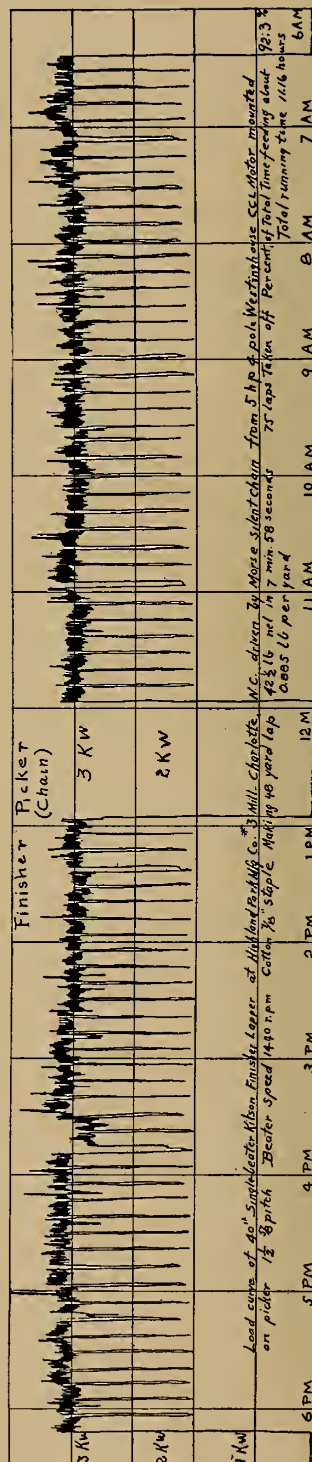


RECORD OF POWER CONSUMED BY KITSON INTERMEDIATE PICKER DRIVEN BY WESTINGHOUSE MOTOR

picker is the history of a day's run of a 5-horse-power Westinghouse type CCL motor, driving through a Morse silent chain a Kitson finisher picker, similar to the intermediate picker just described in all respects except the beater. The two-bladed beater is replaced here by a three-armed carding beater, which has in place of blades heavy wooden bases for rows of spikes, about ¾ inches long, which pull the cotton apart rather than beat it as in the earlier stages. A 48-yard lap, weighing 42.5 pounds, was rolled on this machine in practically eight minutes. The action of the stop motion at the completion of each lap is clearly shown as in the previous case. At 3.30 the small evener belt began to stick and give trouble, and this was not fixed for two laps. Otherwise the record is quite regular.

In frequent instances the attendant would not place a lap on the feed apron as soon as it was needed, and for a short interval only a three-ply sheet was going in instead of a four-ply. The evener would do its utmost to correct for this by speeding up the apron, but even if the amount of cotton were maintained constant, the thickness of the sheet was less and offered less resistance to the beater blades, so that the power fell off very noticeably until the cotton from the new lap again restored normal conditions. This condition of affairs is recorded, for example, at 9.35 A. M., and again at 2.47 P. M. At both these times the interval was about a minute and a half, and the finished lap was probably deficient because of it.

It is interesting to observe how closely such an instrument records all the happenings of a day in this way. In a picker room, where production is being crowded, a meter record, taken by the card-room overseer on any machine in the room, the connection being made without the knowledge of the hands, will show him a great deal about where improvements can be made. It keeps



LOAD CURVE MADE BY WESTINGHOUSE GRAPHIC METER, SHOWING POWER RECORD OF FINISHER PICKER

tabs on the operatives no less than on the machine.

GENERAL SUMMARY

The development of the induction motor to its present efficiency, and at its present low cost, has been the strongest factor influencing the adoption of individual drive in all lines of industry. Its spread to the cotton mill is most logical. The machines are of high rotative speed, and production is an item of supreme importance and is affected materially by the regularity of these speeds. Pulsations or variations are detrimental to the product, but are ineradicable with an engine and belt system. It has been well stated by an engineer who asserts that the benefits of electric drive increase proportionately as the motor is brought nearer to direct connection to the machine. The picker room is the most advantageous department in which to make an installation of this sort, and the development of the drive has been watched with more than ordinary interest, keen rivalry having developed among both the electric companies and the various mills, many strong partisans having voiced their opinions for and against each method as it has been put in operation. It is our personal opinion that the direct drive will ultimately be most favored, though probably not in the exact form now used. As new machines are developed, provision for a more mechanical attachment will be made than can be provided when attempting to utilize old parts. Dust-proof bearings will be used throughout, or possibly some form of flexible coupling, with two bearings on the motor, retaining the present rough iron bearings on the machines. Improvements in details will continue to appear until the final evolution will make the first installation appear very crude. This development has already taken place in the driving of spinning frames and twisters, and the direct-connected motor has replaced all other forms of motor drive and is held in high esteem. We predict as successful a future for it in the picker room.

ELECTRO-MECHANICAL LOCOMOTIVES

By A. P. Chalkley

In view of the high efficiency and other advantages offered by internal-combustion engines and steam turbines, various attempts have been made to adapt such motors to railway propulsion, and in the following article Mr. Chalkley describes some of the recent plans for such machines. At the same time attention should be called to the fact that recent improvements in the steam locomotive, as indicated by accurate tests, have resulted in the attainment of much higher efficiencies than were formerly believed practicable. The tests at St. Louis, and in the testing plant of the Pennsylvania Railroad at Altoona, show that the use of superheating and compounding enables the steam consumption of passenger locomotives to be brought down as low as 18.8 pounds per horse-power hour, and of freight locomotives to 20.3 pounds, and these efficiencies should be taken into account in comparing the possible gain due to the use of the electro-mechanical locomotive.—The Editor.

IN spite of all that can be said in its favour, the modern locomotive is a machine of moderate efficiency; a fact which has been clearly recognized by all the greatest railway engineers, many of whom have tried to remedy matters by the adoption of compound engines, which, however, are, on the whole, comparative failures.

In the last twenty years the efficiency of prime movers of every type has increased tremendously, and the running cost of any power plant installed at the present time can in general be guaranteed not to exceed two-thirds of that of a similar equipment fifteen years ago. This is all the more notable in view of the fact that it applies to all powers; the introduction of the Diesel and suction gas engines, having rendered it possible in the case of small and moderate size units, while steam turbines have completely altered the aspect as regards heavy engineering.

There are two directions only, in which this material advance has not been made, namely, in locomotive and marine engineering; and though this assertion must be modified in referring to the larger boats in which the high powers required give the steam turbine an advantage over the older triple and quadruple expansion engine, slow-speed cargo vessels, of which the bulk of the world's shipping is composed, are practically no more economical if built at the present time than they were a decade back.

The reasons of this marking time in these two curiously dissimilar instances are totally distinct, and yet the most promising remedy is the same in both. The slow-speed vessel is debarred from taking advantage of the employment of highly efficient steam turbines, chiefly because the latter must run at a much higher speed than is possible with the present design of propellers, in order to obtain better results than are given by ordinary reciprocating engines. The locomotive engine, on the other hand, suffers from the fact that it must almost of necessity work non-condensing, owing to the limits of space, the presence of oil in the exhaust steam, and the comparatively small economy that would be effected if a condensing plant were installed.

There are many difficulties in the use of steam turbines, Diesel oil engines, or suction gas engines for direct driving of locomotives, since they are all more or less constant speed, non-reversible engines, and the most workable alternative seems to be the employment of electricity, to act not only as a reversing gear but also as a means of obtaining an economical range of speed and the requisite variation of torque. This proposition, at first sight almost prohibitively complicated, appears in a

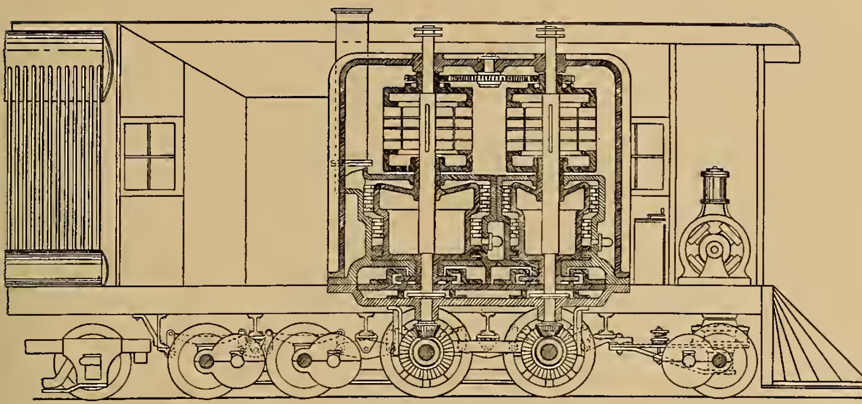


FIG. 1.—SECTION OF THE MC NULTA STEAM-ELECTRIC LOCOMOTIVE

more and more favourable light the closer it is examined.

In broad terms, the arrangement of a self-contained electric locomotive is to have one or more electric generating sets, which deliver power to motors driving the axles of the engine, the dynamos being direct-coupled either to steam turbines, Diesel or gas engines. All radical changes as are involved by such a system must be justified by very greatly increased economy, or they are valueless, and the extra complication will not be tolerated, and before describing any of the various systems of electro-mechanical drive, the assured saving in running costs must first be analyzed. The more strictly parallel case of a steam turbine arrangement may be taken first, this being practically only for very high-power locomotives and for trains where as much as 700 horse-power may be required for lengthy periods. Ordinary locomotive engines, capable of developing this power, seldom take less than 30 pounds of steam per indicated horse-power hour, which is a figure generally agreed upon as a fair average, but to present the best case we may allow 28 pounds per indicated horse-power hour. Taking the overall mechanical efficiency, as 90 per cent., which is a high value, the steam consumption per axle horse-power hour is 31 pounds, and the axle horse-power of the locomotive is 630. The amount of steam used per hour is $700 \times 28 = 19{,}600$ pounds.

In a steam-turbine arrangement eight motors of, say, 80 horse-power each could be employed, and, allowing an electrical transmission efficiency of 90 per cent., the alternator would have to be capable of developing 710 electrical horse-power, or about 530 kilowatts. The steam consumption of this machine would be less than 25 pounds per kilowatt hour (and considerably less if superheat be employed), so that the amount of steam used per hour will be not greater than $520 \times 25 = 13{,}250$ pounds, which shows a saving of 6.350 pounds, or 32.5 per cent., in favour of the turbo-electric system. It will be admitted that the above figures show the reciprocating engine in its best light, and that even at lower powers, when the efficiency of the turbine drops slightly more than the former, the economy will be more than realized.

The Diesel engine arrangement may be examined more in detail, as it is probable that this system will be more suitable for the average conditions which obtain on English railways. Considering a four-hours' run at 50 miles per hour of a train of about 250 to 300 tons, requiring an average drawbar pull over the whole

distance of 1.5 tons, the axle horse-power needed is about

$$\frac{1.5 \times 50 \times 5{,}280 \times 2{,}240}{60 \times 33{,}000} = 450 \text{ H.-P.,}$$

or allowing an efficiency of 90 per cent., as before, the engines must develop 500 indicated horse-power. If the coal and water consumptions be taken at 3 and 30 pounds per indicated horse-power-hour respectively, the fuel burnt on a four-hour, non-stop run would be 6,000 pounds, and the water used would be 60,000 pounds. The price of coal to a railway company is about 12*s.* per ton, and water is about 6*d.* per 1,000 gallons, so that the running cost over the 200 miles would work out at 32*s.* 1*d.* for coal, and 3*s.* for water, or a total of £1 15*s* 1*d.*

With the Diesel arrangement there would be four 110-horse-power motors on four axles, and allowing an overall efficiency of 80 per cent. the power required to be generated by the engine is 550 brake-horse-power and the total for a four-hours' run would be 2,200 brake-horse-power hours. The guaranteed oil consumption of a Diesel engine of this power is between 0.4 and 0.5 pound per brake-horse-power-hour, and if we take the latter figure, the oil consumed on the journey will be 1,100 pounds. The present market price in London of crude oil is under 45*s.* per ton, so that the cost for the run will be 22*s.* The saving in the latter case, therefore, works out at 13*s.* 1*d.*, or about 37 per cent. of the cost, or to put it the other way round, the steam system costs nearly 60 per cent. more than the Diesel equipment. No allowance has been made for cooling water in the latter case, since this would be used over and over again, after being passed through a cooler on the engine, and the only water lost would be that accidentally wasted, a negligible item as far as cost is concerned.

Having demonstrated the saving to be effected, we may proceed to examine some of the systems which will shortly be put into operation. The first proposal was made nearly

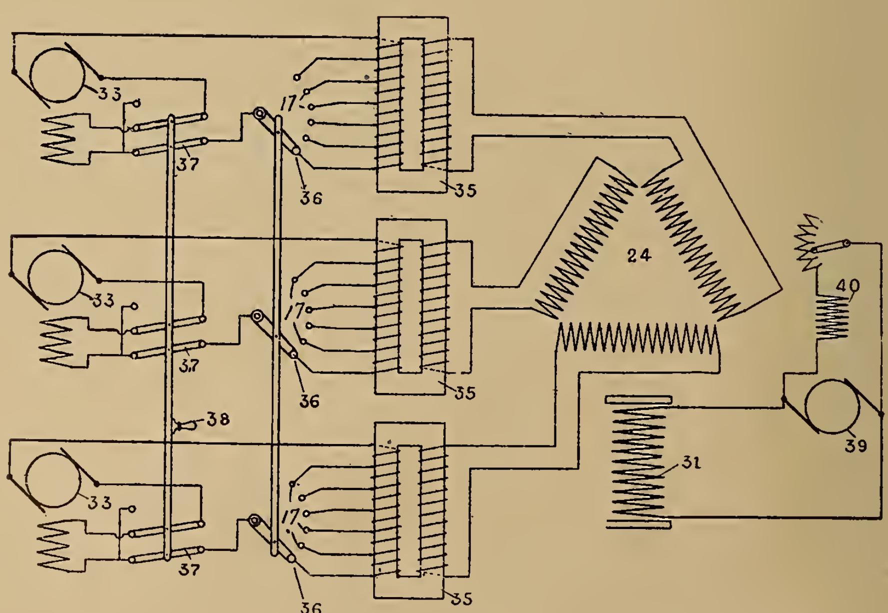


FIG. 2.—CIRCUITS OF THE MC NULTA STEAM-ELECTRIC LOCOMOTIVE

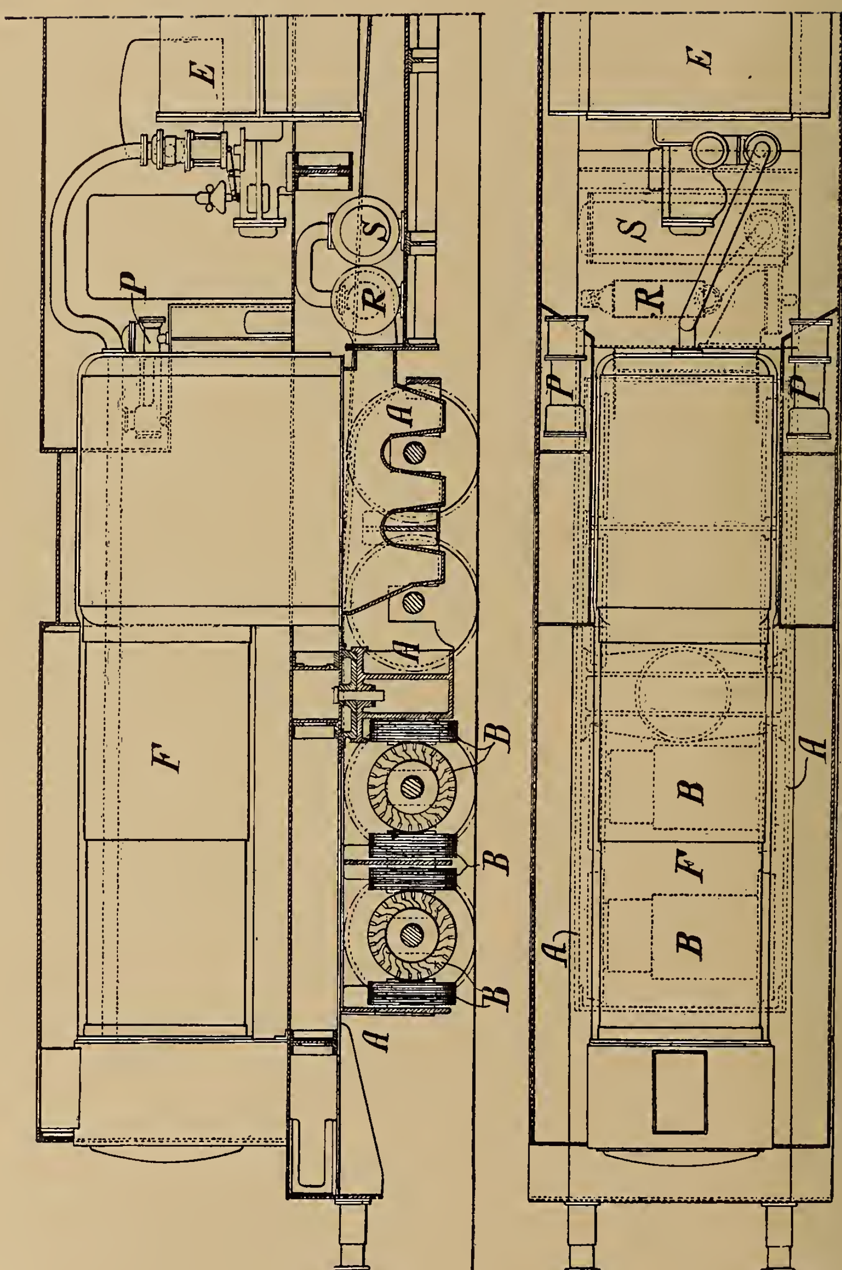
twenty years ago; the arrangement consisting of a reciprocating steam engine coupled to a generator on the locomotive, the electric power being transmitted to motors on the axles of the carriages, but, as may be imagined, the small economy was not held to warrant the extra cost and complication.

In 1905 a system was patented by Mr. McNulta, which apparently has never been put into practice, but which possesses great originality. Two vertical turbines of the Parsons type were coupled to the external armatures of alternators, the internal field magnets being keyed on to shafts revolving within the turbine shafts and coupled to two driving axles of the locomotive through bevel gearing. There were also motors on the other axles, taking their power from the secondaries of static transformers, the primaries of which were connected to the terminals of the alternator armatures. The field magnets of the alternator were excited from a separate steam-driven exciter. On starting up the turbines, the outer armatures were rotated, and when the field magnets were excited current was generated in the armatures and delivered to the motors through the transformers. The field magnets also revolved, and, as the speed of the locomotive increased, the relative speed of rotation of the magnets and the armatures decreased, and the voltage at the armature terminals (and consequently the torque of the motors) diminished, that is to say, the highest torque was developed at the start and was reduced as the speed rose. Variations of torque, according to the conditions, were obtained by a controller, which altered the ratio of transformation. A sectional elevation of the arrangement is shown in Fig. 1, and a diagrammatic illustration of the circuits in Fig. 2.

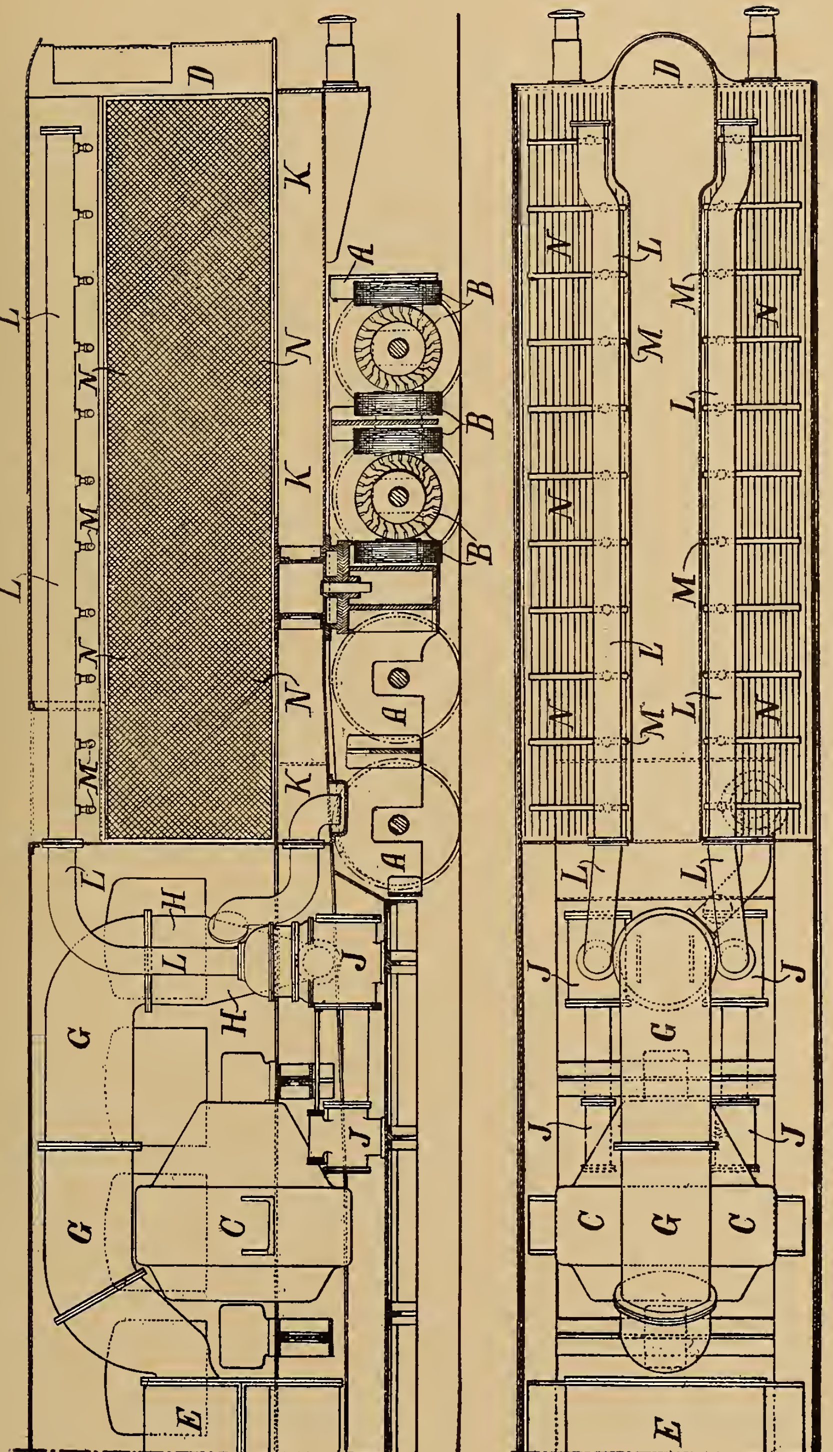
Probably the first electro-mechanical locomotive to be built is now being constructed at the works of the North British Locomotive Company at Glasgow, in accordance with the designs of Messrs. Reid and Ramsay, and tests will shortly be carried out. A single horizontal turbine of the Curtis type is employed to drive a direct-current series dynamo, from which power is taken to four or more series wound motors coupled to the driving axles through gearing in oil boxes. The steam, after passing through the turbine, enters a jet or ejector condenser, where it is condensed and mixes with the condensing water. The whole is then pumped by means of turbine or reciprocating pumps through the cooling apparatus mounted on the front of the engine, so as to obtain the full blast of the air when the train is in motion. Cooling may also be facilitated by a turbine-driven fan, forcing the air over the water, the same or another fan being used to cause a draught in the boiler furnace. The water, after being cooled, drops by gravity into a supply tank, and part is pumped back into the boiler through a feed heater, and part used for condensing purposes again, the supply tank being of sufficient capacity to carry the water required for the boiler and to make up any losses in the condensing water.

Figs. 3 and 4 show the general arrangement; Figs. 3a and 4a being the front end, and Figs. 3b and 4b the back end of the locomotive. *F* is the boiler, *E* the turbine, *C* the generator, and *B* the motors. The jet condenser is shown at *H*, K being the supply tank, *N* the cooler, and *J* the condenser pumps, which in this case are reciprocating. The feed pumps are at *P*, *R* is the turbine-driven fan, and *S* the feed heater.

A further and most promising system which will soon be put into operation is that of Mr. Durtnall. It is applicable with steam turbines, suction gas engines, or Diesel oil engines, though the latter seem likely to give the best results. The electrical part of the equipment is shown in Fig. 5, as arranged for a six-cylinder, two-stroke Diesel engine as



FIGS. 3A, 3B.—FRONT END OF THE REID & RAMSAY ELECTRIC LOCOMOTIVE



FIGS. 4A, 4B.—REAR END OF REID & RAMSAY ELECTRIC LOCOMOTIVE

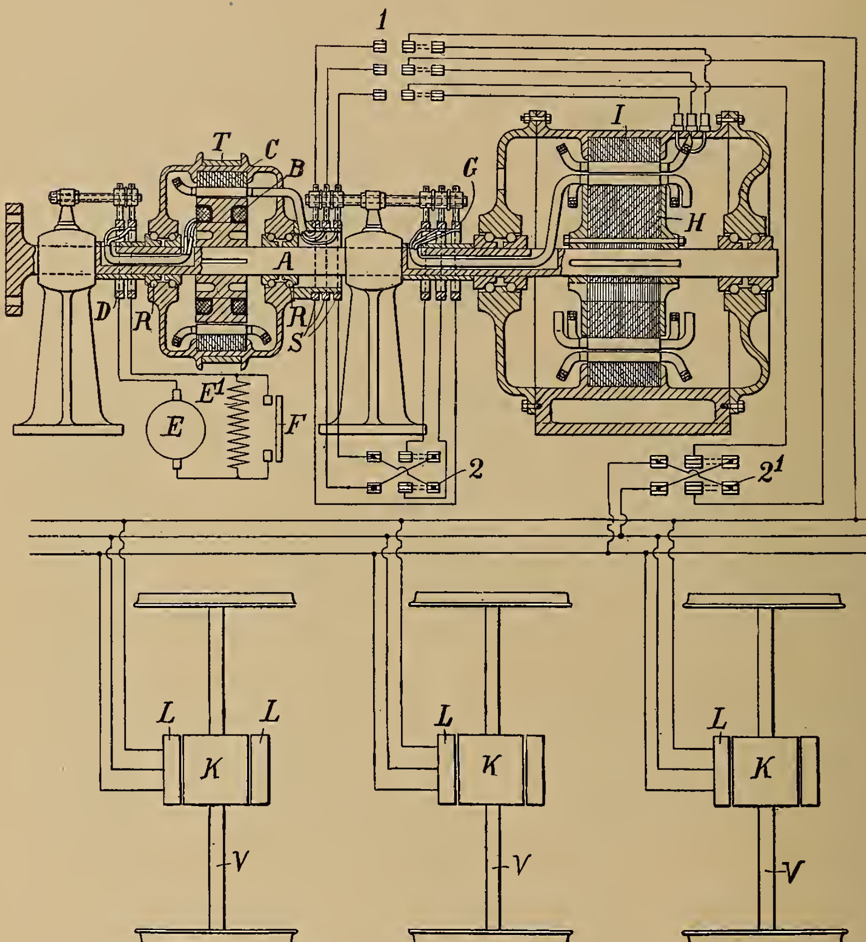


FIG. 5.—THE DURTNALL SYSTEM FOR ELECTRIC TRACTION WITH DIESEL ENGINES

prime mover. The generator consists of two elements, the alternator, with armature *B* and field magnets *B*, and the transformer generator, with primary *H* and secondary *I*, and the squirrel cage induction motors are shown on the axles at *K*, *L* representing the stators. Both the rotating elements of the generator are on the same shaft, *A*, which is coupled to the prime mover; 1, 2 and 2′ are switches, and *E* is an exciter which delivers its current to the field *B*, through the slip rings. The design of the machines depends on the conditions of running and the speed required. If the prime mover is a Diesel engine working at, say, 400 revolutions per minute, the alternator may be a 4-pole, the transformer a 12-pole, and the motors 20-pole machines. To obtain the lowest speed of the motors, the current is taken direct from the armature of the alternator to them, when a synchronous speed of $400 \times 4 \div 20 = 80$ revolutions per minute is produced. For the next speed the current from *T*, instead of passing direct to the motors, is led to the primary of the transformer generator, so that the flux due to it revolves in a direction contrary to that produced by the rotation of the primary

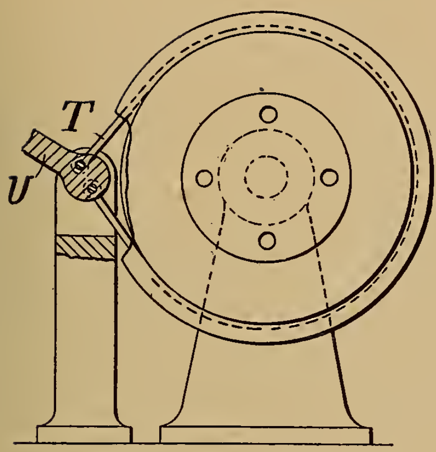


FIG. 5A.—MECHANICAL SPEED CONTROL

itself. The periodicity of the current taken from the secondary of the transformer generator is, therefore, equivalent to that of an alternator with 12 minus 4, i. e., 8 poles, so that the synchronous speed of the motors is 400 × 8 ÷ 20, i. e., 160 revolutions per minute. The third and top speed is reached by sending the current from *T* into the transformer generator, so that the direction of rotation of the flux due to it is the same as that of the primary of the transformer generator. The synchronous speed of the motors is now the same as if the power were obtained from a 12 plus 4, i. e., a 16-pole generator, and will be 400 × 16 ÷ 20 = 320 revolutions per minute. Intermediate synchronous speeds can be obtained by mounting the armature *T* on bearings, and providing it with a pair of slip rings, as shown in the figure, and varying the speed mechanically to any required extent. Reversing is accomplished by simply reversing two phases by means of a change over switch. The figures given above are, of course, purely illustrative, and it would probably be found in most cases that higher speed motors would be more satisfactory and economical, gearing being employed to reduce the speed of the axles to the workable limit.

ENGINEERING WORKS IN CONCRETE

By Day Allen Willey

One of the important results of the exhaustion of certain materials of construction appears in the substitution of later substances and combinations for those that have become too costly or unsuitable for general use. Thus, for many purposes, large timbers have been found unavailable because of the expense attending their employment, and the rolled steel girder appears to take their place. In like manner the improvements that have enabled Portland cement to be produced in quantity, at moderate cost, has led to the development of concrete as a substitute both for timber and for cut stone, while the use of steel reinforcement in concrete construction gives to the combination a resistance to tensile as well as crushing stresses which gives it far wider uses than were practicable for either element when used separately.

In the present article Mr. Willey reviews the growing use of concrete, and shows the extent to which it is enabling works otherwise impracticable to be made both possible and remunerative, and calls attention to the lines along which engineers, manufacturers, and financiers must look for further successful developments.—THE EDITOR.

THE adage that there's nothing new under the sun may be considered as imaginary from the standpoint of the engineer, when we remember the great revolution that has taken place in various industries, due to the perfection of skill, associated with the ingenuity, the originality, that is characteristic of the engineer of to-day. It is needless to refer to the evolution in connection with transportation, industrial power, the application of electricity, the simplification of mechanism in general by increasing the power with a reduced weight of metal. In some respects this evolution has been wonderful, as the laymen would put it.

But there is nothing more worthy of study than concrete. The world says it is new. That is true as to its general use, but it is really an illustration of the adage that introduces this article. When the archæologists began uncovering the ruins of the Old World, they found massive walls of brick and stone, tiling of peculiar construction, but they also found remains of great aqueducts and viaducts of composed elements, assembled by human efforts, so compactly assimilated that where the excavating tool might crack or fracture the stone, this composition resisted the heaviest blow not merely because it was hard but of actually more tenacity. We are still ignorant of the extent to which concrete was formed by the engineers and architects probably before the Christian era in various structures. That the great reservoirs that brought water to irrigate Babylonia included concrete is a fact now established beyond contradiction. Only the wars, which ruined them, have prevented their employment to this day in turning the desert into fertility. Traces of the concrete building of the ancients are continually being found in Europe, and how far their efforts extended remains to be discovered.

It is strange, considering the history of this material, that its importance and value should have been neglected until recent years, especially the truly great variety of purposes for which it cannot only be used but for which it is an actual necessity—creations in which it can be utilized entirely or with other material.

Dwelling briefly on staple material for building construction, in the general sense of the term, we include stone of all kinds, except shale and other friable formations impracticable for the builder's use. Certain clays are moulded into brick. These elements may be replaced by wood where forests are available, and it is needless to say that stone, brick and wood are combined in formation in

A CONCRETE HOTEL UNDER CONSTRUCTION AT ATLANTIC CITY. TRUSSED CONCRETE STEEL COMPANY, DETROIT

an enormous variety of ways. Iron and steel must be, of course, added to the group of formative elements, since they constitute parts, especially in the erection of large building structures as well as railways, bridges, marine work ordnance and miscellaneous mechanism. At this point in the discussion the question arises as to the availability of an element. The world contains great beds of building stone. The United States, especially, has been benefited in the abundance and variety of this material. It has been said that the great architectural piles of Europe exist in such numbers because the localities contained sufficient stones

A PORTABLE CONCRETE MILL USED IN THE CONSTRUCTION OF AN IRRIGATION CANAL

often in the vicinity of the site. As to wood, Europe's preserves to-day are far below the percentage of demand, and lumber must be imported. Clays for brick are also limited, although when the engineers excavated the ruins of the Campanile they found that its foundation rested partly on a buttress made of a brick that had withstood the enormous pressure of the tower over a 1,000 years without decomposing, and constantly saturated by the chemicals of sea water. But clay, like wood, is a rare material for the foreign builder, and the stone quarries are being rapidly depleted while the European furnace and mill are yearly producing a greater and greater output of architectural material in steel; thus the artificial is superseding the natural.

And thus is explained, in part, why the importance of concrete has been appreciated in Europe far more than in the United States, and, strange as it may seem, in more ways. Visit the English seaports and you will see harbours literally framed with concrete reinforced by steel. The rock fill or masonry crib or quay is falling into disuse. Even the piles and other supports of the quays, breakwaters, perhaps the wharf terminals, are of concrete, moulded to the exact dimensions. Coast cities have actually been made seaports by artificial basins protected from the ocean by walls of concrete reinforced by steel, but without a cubic yard of ordinary masonry. The same is true with the recent harbour facilities completed by the North Sea countries, but the reason is simple. The supply of sand, the base of this artificial stone, is limitless. Cement in abundance is manufactured in Britain and on the Continent; water, the last ingredient, is to be had merely for the pumping. So the age of concrete has succeeded the "stone age" in the enlargement of Europe's facilities for marine commerce, an expan-

sion that amazes the expert in harbour improvement when he sees these great works for the first time.

Such is but an instance of the development in the use of concrete in the Old World. The sewers are being lined with it, also subways in cities. Concrete is replacing natural stone railway viaducts. In the form of pillars and posts it is indispensable for supporting buildings. Even concrete barges have been built in Italy, craft of such economical and durable construction that other European countries are considering the substitution of concrete for wood and steel for the vessels plying on their inland waterways.

The first thing that is noted in the study of this subject in the United States is the unlimited supply of sands and aggregate which are suitable for this composition. The sand occurs, as shown by a geological study, in many parts of the country where wood, stone and brick for making clay are not abundant. No country has such advantages for making concrete of various kinds as the United States. West of the Mississippi river so many States, destitute of timber growth and natural stone, have such beds of the base for concrete that the supply is ample to use this material in any form which has as yet been conceived by the engineers. To summarize the conditions, it may be said, without exaggeration. that no country in the world has a greater opportunity to utilize this compound in its various forms than the United States, and that nowhere can it be manufactured at such a low cost.

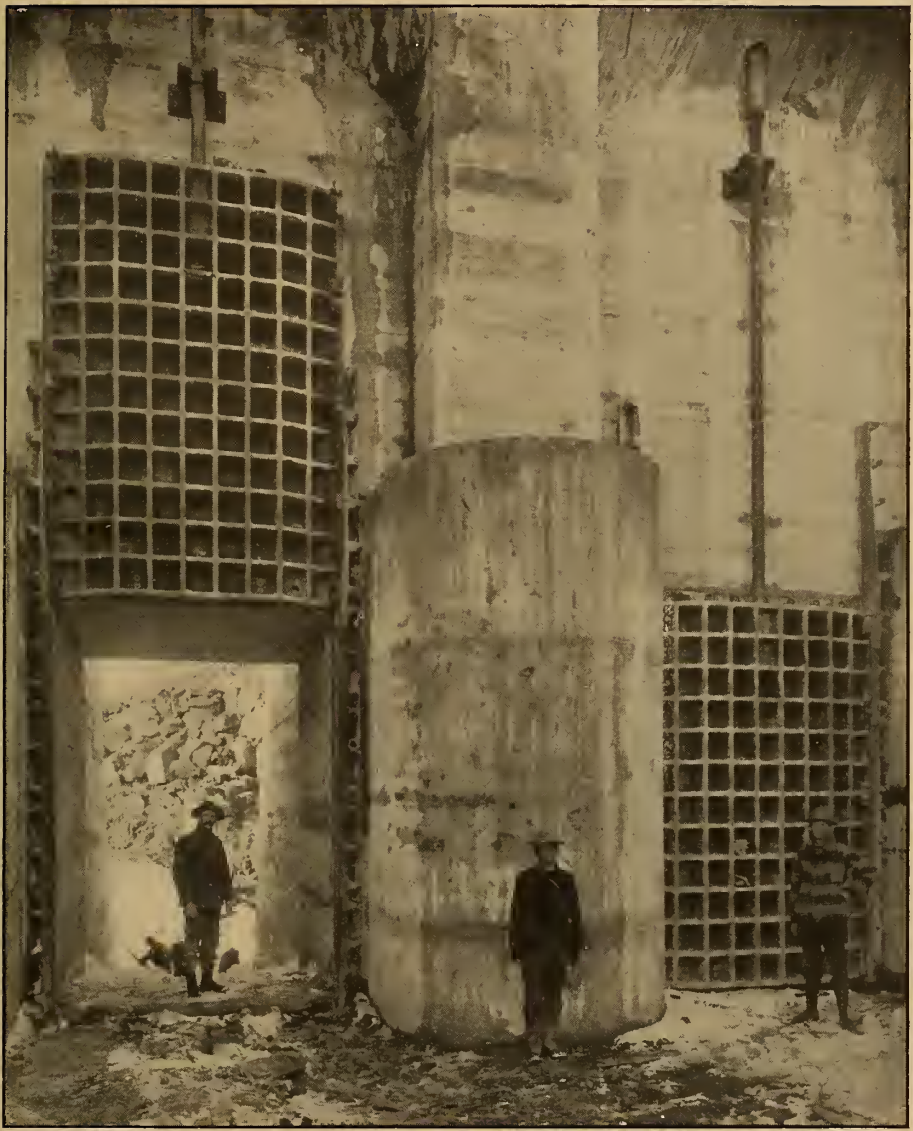
Analysis of the purposes for which concrete is not only available but in many cases is absolutely necessary, proves that Americans have neglected a great opportunity in not utilizing it on an extensive scale in the past. If a comparison was made of the cost of bridges of all types, canals, tunnels, and the many varieties of buildings in which concrete could be sub-

AN IRRIGATION CONDUIT OF REINFORCED CONCRETE UNDER CONSTRUCTION

CONCRETE DIVERSION CANAL ON THE TRUCKEE IRRIGATION SCHEME, NEVADA

stituted for brick and wood, the figures would show that the expense of concrete as a substitute would have greatly reduced the outlay. In many instances it would have been more durable and advantageous, and the expense and time of construction saved to a great extent. It is only necessary to call attention to the simple process of moulding the material into various forms, as an illustration of this fact, also the small amount of human labor required to do a certain work with concrete as contrasted with the use of other material for the same purposes. Another feature of economy is the expense of power machinery for transferring and conveying, such as derricks, tramways, and other apparatus for lifting heavy weights in the construction of low buildings.

It would be impossible to enumerate all of the purposes for which concrete can be utilized. What has been done in Europe is one indication, but in America the variety of work which can be done with it is far greater. It has been said that we have reached the age of concrete, but at present we are only beginning in the use of this material, and no one can tell to what extent it will be used ten years hence. Already, in building construction, it has been largely depended upon in the erection of factories of various kinds. In New York City stands an office building well termed "monolith," since it is merely a great mould of this material. The use of concrete in supports of various kinds, either with or without steel reinforcement, is shown in the many types of pillars, piles in submarine work, concrete foundations for dwellings, as well as stores, while the skeleton of the office building is now being constructed of concrete and steel, instead of the metal skeleton which came with the era of the tall building. The use of concrete for storing heavy material is



CONCRETE WEIR AND GATES, SHOWING SIZE AND REINFORCEMENT

instanced in the construction of grain elevators at different points along the Great Lakes, since the material has such a lateral pressure resistance. Warehouses which must sustain great weight are also being constructed not merely with concrete walls, but concrete framework, and the floors themselves may be of the same material.

Projects that show economy in the use of concrete are the building of bridges. Structures which have been finished in this country for a series of years verify the statements of many engineers that the material, while much cheaper to use than stone, may be regarded in many instances just as durable, and, in some instances, more durable, for the rea-

son that in certain climatic conditions the masonry is far more affected than concrete, owing to the compactness of the latter material. As to standing the stress and strain of train service, there is no doubt but what it is equal to masonry in most instances and will remain in service longer periods without repairs than steel work. The faith of the engineers in concrete has been shown especially in the West, where the formation of concrete bridges is shown in practically every feature of railroad work. Possibly, a better test of the material is in the aqueduct. Here it must sustain a continual water pressure far greater in many instances than the weight of the passenger train. As stated, this pressure is constant. It is unnecessary to detail some of the concrete aqueducts which are now being used in connection with irrigation in the West, or the structures which have been built over large rivers, even the piers reaching the river bottoms being of the same material. The highway bridge is still being built of steel and wood as well as stone, in places where the elements for making concrete are so abundant and diversified that the sand and gravel may be gathered from the bottom of the creek or river and mixed with cement on the site. Thus the necessity of carrying steel or wooden bridge work perhaps a 100 miles by rail and putting it in a position with machinery is entirely avoided, the concrete workers making the forms or moulds of timber on the spot, the only false work needed being a temporary dam and scaffolding. In some cases a bridge may be built over a small stream, without even the expense of constructing a coffer dam. In the building of elevated structures for conveyance of every kind there is no question but what there is a great future for concrete, owing to the advantages which have been outlined.

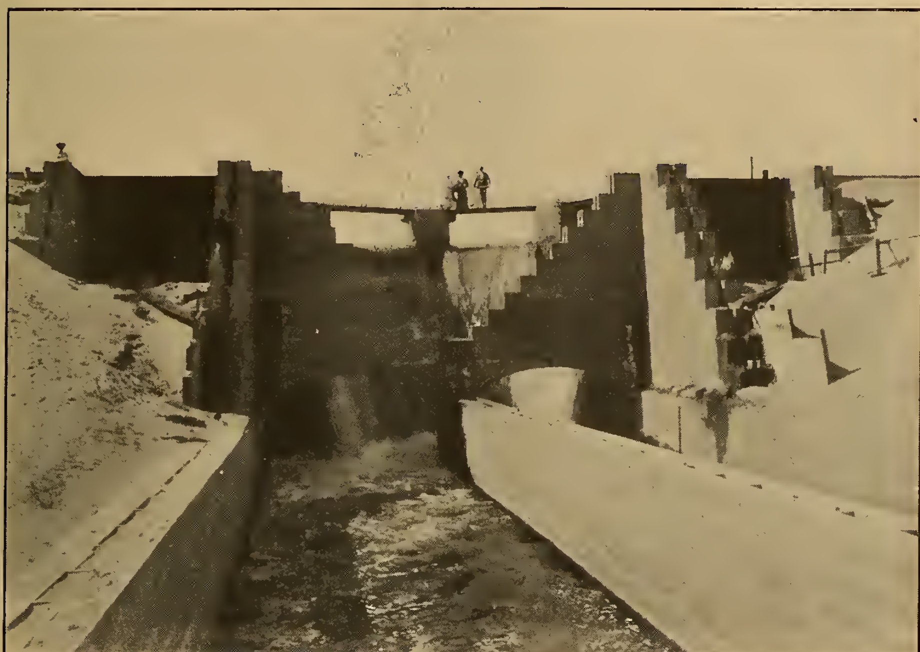
Within the last few years the necessity of concrete for underground and submarine projects has been demonstrated beyond question. It is believed by experts of national reputation that the achievement, for such it was, of tunneling the Hudson river would not have been successful without the use of this material, as no construction of stone, brick or metal would have served the purpose, owing to the formation of the bottom of the river and other conditions. The same is true of the East river tunnels connecting New York and Brooklyn, but in other parts of the United States we also find works of interest which are interesting illustrations of what the engineer has done with this material, as, for example, the tunnel which brings water into the city of Chicago for domestic purposes from Lake Michigan. This conduit of steel and concrete rests upon a soft sand bottom, and is carried out to such a point in the lake that a continual supply of clear water is insured. In the West another project of interest is the connection of Canada and the United States by the tunnel under the Detroit river, in which concrete was absolutely necessary.

In connection with the irrigation of arid lands it has been necessary for the engineers of the U. S. Reclamation Service to go through hills and mountains, in order to carry the water for distribution to the irrigated lands. One instance of this sort is the longest underground canal for carrying water in the United States, extending a distance of no less than six miles, being served by the Gunnison river, a mountain stream in western Colorado. Only by this underground conduit could the water of the river be diverted, and it is now serving no less than 200,000 acres of land in the Uncompahgre valley, which has been a portion of the American desert. This fact is worth noting, for the reason that it is one of the most notable engineering feats in the history of the United States, and without the use of concrete for lining the in-

terior of the canal as well as the distributing channels the work would have been impossible.

Among the unique ways in which concrete is now being employed is in connection with mining operations. The quality and durability of the material give it advantages over wood in the shoring of galleries and other openings, while in formation, where there is danger of cave-ins, the concrete lining is being used very extensively. A new use, however, for it has been demonstrated by a shaft planned to reach a deposit of coal in Pennsylvania in a formation so water-soaked that no ordinary excavation could be successful and a shaft lined with iron or steel could not completed. The coal bed was covered with a bed of rock extending 80 feet below the surface. Under this for a depth of no less than 700 feet the formation is soaked with drainage. As the coal bed is a very large one and of a high grade, it was determined, if possible, to reach it with a shaft with concrete walls, to be reinforced with steel. To cut into the rock, a device termed a steel-cutting shoe was made.

The shoe was placed at the bottom of an excavation 15 feet deep, the resting place of the shoe being accurately leveled. Forms were then erected on the shelf and concrete poured in in the manner followed in the filling of any concrete wall. Steel reinforcing rods were placed at regular intervals in both directions. The shoe was thus forced through the soft earth by the weight of the wall; and, as the shaft sank, the wall was built up, the forms being removed as soon as the concrete set and replaced above to be refilled. The shaft kept sinking of its weight as its height increased, the walls always being kept a little above the ground level. The greatest problem encountered was in keeping the shoe absolutely level, so that one side of the shaft would not sink faster than



CONCRETE WORK ON POWER DROP ON MAIN CANAL OF THE TRUCKEE-CARSON PROJECT, NEVADA

CHAPEL OF THE UNITED STATES NAVAL ACADEMY, ANNAPOLIS

the other. The rock bed was reached about 80 feet below the ground, and as this stratum was not level, the walls of the shaft had to be propped on one side, and a concrete joint formed between the bottom and the bed of rock. This joint was made absolutely waterproof. Then the engineers began blasting through the rock and a concrete lining was placed in the rock portion of the shaft, making it of uniform diameter and giving it a smooth operating interior surface. In carrying out this novel mining work more than 3,000 cubic yards of concrete were utilized, in addition to the steel the quantity of metal required being about 145 tons. The upper section of the shaft might be called a huge caisson, since so much of it sets in a water-soaked formation.

The description of this shaft is notable, since, as already stated, it shows how mineral deposits can be reached and mined by the use of concrete in lining the openings, where the natural formation would permit of no other successful method.

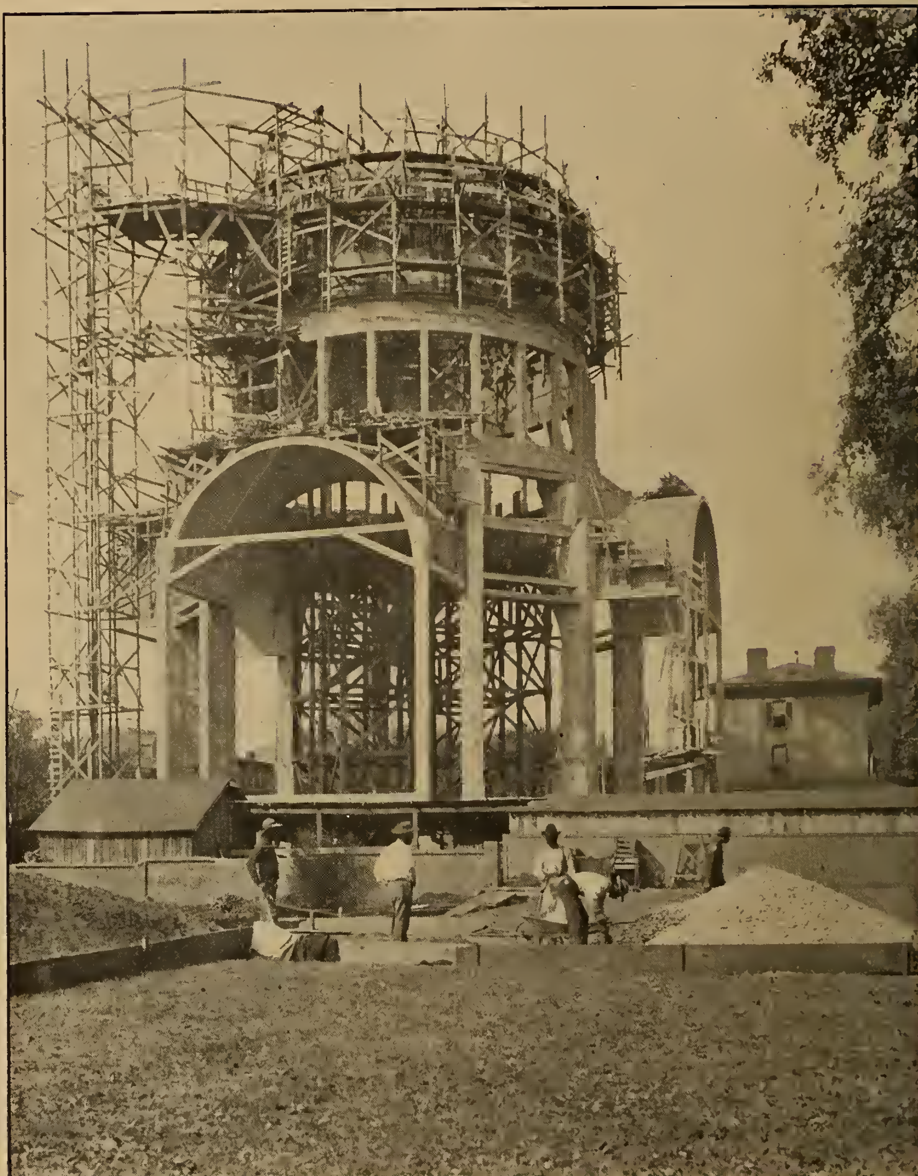
But the necessity of concrete from the building standpoint has caused it to be utilized in place of other material in some very unique ways. The chapel of the United States Naval Academy at Annapolis is one of the most remarkable illustrations. While the exterior of the building is of pressed brick, with a natural stone foundation, the framework is entirely of reinforced concrete, the only way

in which the plan of the architect eliminating all pillars and columns in the interior, could be executed. The chapel is one of the most picturesque structures of the Naval Academy and imposing in its proportions, but without the concrete arches supporting the roof it could not have been designed of its present majestic proportions. In fact, the chapel is considered by architects and engineers a most interesting example of modern architecture yet attempted in this country, really rivaling the famous Pantheon of Rome in its height and size, as its dome reaches to a height of 210 feet, 70 feet higher than the Roman structure. It may be said here that the Pantheon dome has a framework of "beton," the ancient concrete, and has thus been supported since the year 123 A. D., or nearly 1,800 years. The manner in which the concrete was placed in position in the naval chapel is what makes it so unusual. When Camille Siquot, the French engineer, came to Annapolis to supervise the building of the chapel he was laughed at by many who heard of the manner in which he intended to erect the concrete building. He proceeded with his work and the completed building is a guarantee that he knew whereof he spoke. The building is practically the shape of a Grecian cross, the central portion of which has been rounded. The floor space of this is 83 feet in diameter, which, with the transepts, gives a floor space 116 feet square. Each of the transepts is built in the form of an arch, they being four in number. As each of these arches has but four legs about two feet each in diameter, it will be seen that the enormous series of domes which continue upward 210 feet stand upon rather slender support.

The pillars, or legs, were built in much the same manner as any other concrete structure. When the arches were started, however, instead of securing the wooden frames, which are generally held in position by scaffolding, to hold the great weight of concrete which is placed in position to form the arch, no artificial aids were employed. The wooden boxes, or molds, were added in short sections, the longest of which was less than two feet. As the work progressed, and the arch took shape, it appeared as if it must break and fall by sheer weight. Work progressed from both sides till the two points met at what, in masonry, would be the keystone, and were then joined together by the simple addition of more concrete. The weight must have been something enormous, but in spite of this fact they retained their position through each successive stage of the work, and, of course, when completed, the danger of collapse was passed. It was in the construction of the dome and the walls which support it that Siquot displayed the greatest skill. It seemed more a work of creation than construction, and stands to-day as an example of what is daily being accomplished along new lines. In this the tensile strength of concrete is given a test more severe than any other to which it has been subjected. Although the dome is a complete arch from every point, it has no support outside of the concrete of which it is made and small iron rods less than half an inch in thickness.

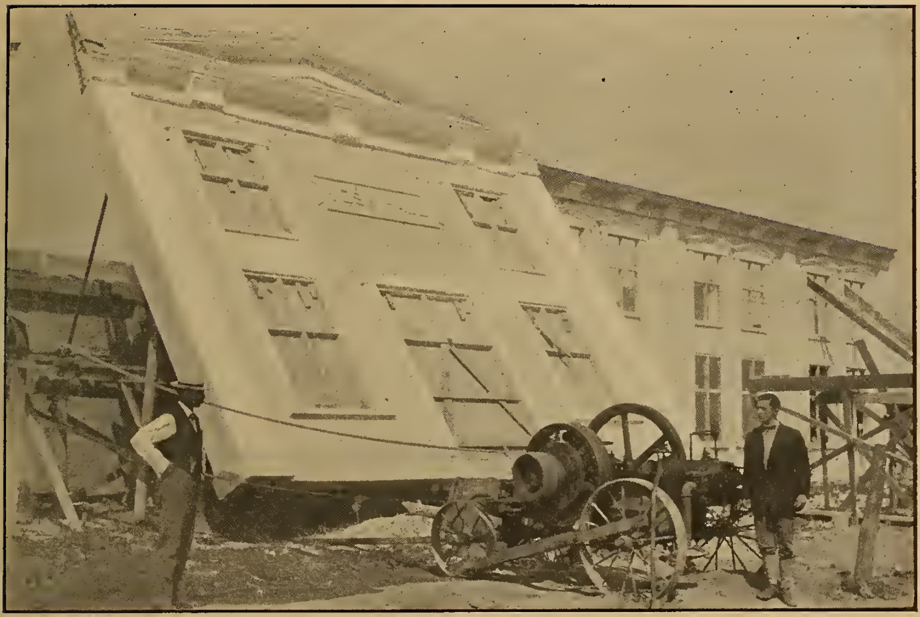
The dome gradually grew in height until it finally bent far in from every point and became perfect in outline and figure. Except for the hanging scaffold the men were standing on a concrete wall almost level and held from a drop of over 200 feet by the mere shell of five inches. All this had been accomplished without the aid of a particle of support from the underside and by nothing more than the arched shape of the material.

This is admitted to be the most notable illustration of a concrete-framed building in the world, but the material has also been utilized because nothing else was suitable on a site which consisted merely of a sea beach. A hotel of 10 stories was



CONSTRUCTION OF THE CHAPEL AT THE UNITED STATES NAVAL ACADEMY, ANNAPOLIS

designed on the sea front of Atlantic City. The foundation consisted merely of sand, into which the tide forced its way at a depth of 10 feet below the surface. Such was the site on which the engineers prepared to erect the hotel. They secured foundations by sinking caissons, in which concrete piers were moulded. Then was erected, story by story, a framework, not of steel but of concrete, reinforced with steel rods. The junction of the vertical and lateral parts of the framework was enclosed by steel clamps, into which the columns and girders were set and held by bolts. Floor by floor this framework was erected, to be sur-

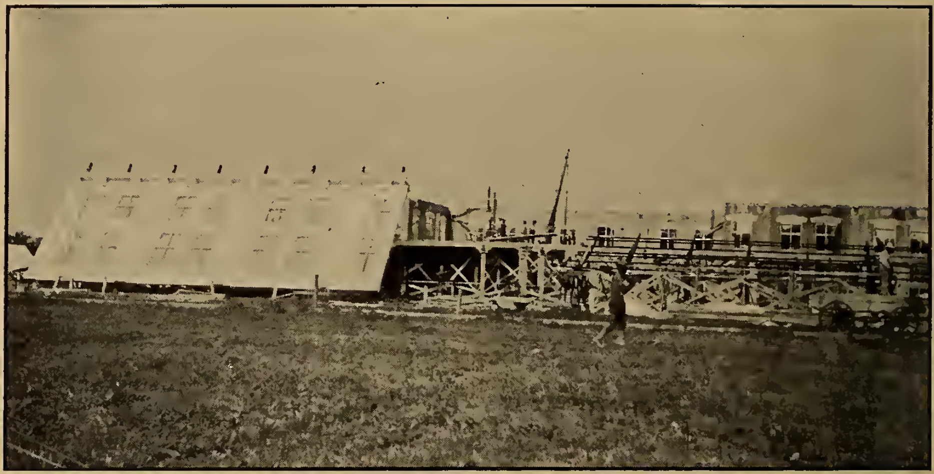


RAISING MESS HALL FRONT AFTER CONSTRUCTION IN HORIZONTAL POSITION

mounted by a massive dome of the same material work. The floors and partitions were also of tiling and concrete, making the structure fireproof. By utilizing this material in place of brick, stone or wood, really a beautiful building was erected on a site where the foundation must needs be entirely artificial.

Another illustration as to the construction of a concrete-walled building, and the quickness with which it can be completed, goes to show the value of this material in time and labour-saving over brick, stone and wood. A series of buildings was erected in Ohio for the State troops, including a barracks. These included a mess hall, utilized for cooking and for serving meals to the soldiers. It is quite large in proportions, being two stories high, the exact height being 26 feet. When the State engineers prepared plans for the camp, the question of using concrete for the principal material was discussed, resulting in a decision favorable to it, but the concrete was utilized so extensively that it may be said the mess hall is almost entirely a concrete creation, much of the interior work being composed of it as well as the entire exterior. When the plans of erection were discussed, the engineer, R. H. Aiken, advocated the moulding of the walls upon the ground and lifting them bodily to their permanent positions, thus avoiding the use of scaffolding, also the lifting of material if the construction was vertical, as in the usual manner. It was finally decided to follow this plan and special equipment was devised for the purpose.

The principal feature in the equipment was a series of specially constructed jacks for raising the completed walls. In starting the building a plaform of 2-inch lumber was laid across steel beams, about 4 feet apart, these beams supported by jacks. The platform was not more than 3 feet from the ground, and lay inside the borders of the proposed building. Four-inch boards were set up on the four sides to complete the form. On the platform were placed the window frames and the reinforced concrete cornice, which was cast in 6-foot sections, 3 feet wide.



A CONCRETE WALL PARTIALLY RAISED

In this case special ornamental window caps were required, and these were cast separately and placed in their proper positions on the platform. Then concrete of one part cement, one and a half to two parts sand, and four parts crushed stone was poured on to the platform in very wet form.

So rapidly did the concrete solidify that an examination only 48 hours after it was placed in the moulds showed that it had hardened sufficiently to set the wall in its vertical position. In spite of its weight, the only mechanical power needed was that secured from a small portable engine developing but five horsepower. The engine was hauled to a platform which supported a series of jack screws. A steel shaft extended to all of the jack screws, a belt pulley for revolving the shaft being mounted upon its end. The engine was connected with the shaft by means of the pulley and belting, and slowly the wall was tilted into position. The platform supports were so accurately placed that the foot of the wall swung to its position on the foundation at precisely the right line, and, when four hours later, the slow-moving screws had raised the wall to a vertical position, every line was plumb. This operation was repeated until all the walls were up. The reinforcing rods were allowed to protrude at the edges of the walls and interlock at the corners of the structure. The rods are twisted together, and an 8-inch board, the only false work used in the construction of all the walls, is placed inside the corner, concrete is poured in, a neat joint made on the outside corner, and the two walls are thus bound firmly together. As already stated, the mess hall is 26 feet high, with an average thickness of 4 inches, while the pilasters are 10 inches and the sills 6 inches. Consequently the wall represented a very heavy weight, but so accurately was it elevated that when in position it did not deviate a fraction of an inch out of a straight line and rested squarely upon its foundation. As far as known, this is the first successful attempt to mould a concrete building in sections, then to merely lift the sections into their permanent positions; but it will be recognized that the idea is practical in many other forms of concrete construction and is really a revolution in the construction of warehouses, dwellings, and other work where this material may be used.

In an analysis of various ways in which concrete is of importance is the extent to which it has aided in

what is known as irrigation. In fact, the work of storing water and distributing it upon the desert and arid lands of this country could be done only in a few localities, and irrigation greatly limited if we did not have this material available. When it is stated that concrete has been employed in every important irrigation project thus far undertaken in the United States, a better idea of what it means to the people in general may be gained. The most noted authority on irrigation, Hon. Francis G. Newlands, has made a life study of this work, and, according to his estimate, fully 500,000,000 acres of land will be added to the American farms under the present law, which, it might be added, was framed by Mr. Newlands, who may be considered both an agricultural and irrigational expert. This means fully 1,000,000 homesteads for a population of at least 5,000,000 people, but the reclamation of the lands now desolate and productive of no crop whatever, the reservoirs built and being built to store the water of the lake and river for irrigation, the canals carrying the water to the irrigated districts and many of the laterals and ditches served by these canals are dependent upon concrete, as this is the only available material that can be used to prevent seepage and waste of water, and to carry it to the cultivated fields. Not even an estimate can be given of the enormous quantity of concrete that is employed in this way alone. Even in places where a natural gorge forms a location for a reservoir and the dam constructed of masonry, one finds much concrete work necessary, possibly for facing the water side of the dam, for cementing its ends to the natural formation, and for other purposes.

The water from the storage basins could not be distributed without concrete, since much of the surface of the country is so friable that it would act as a sponge in absorbing the liquid long before it reached the area to be irrigated. Consequently, some of the single-canal systems in the

RAISING A CONCRETE WALL

West are from 200 to 300 miles in length, carrying a depth of water from 3 to 8 feet, yet every square foot of the bottom and sides is lined with this material. As to its actual necessity, reference may be made to the Klamath water-works system, conveying water from reservoirs in southeast Washington to what has been a portion of the American desert, in what is known as the Klamath Valley. For 20 miles the water passes through a concrete aqueduct held against the hill side by arms of reinforced concrete anchored into the rock. Owing to the formation of this river it was impossible to construct a canal in any other manner, but tests were made that showed that the concrete had the necessary strength and resistance to pressure. This canal is composed of sections of the material moulded to the proper form, in the valley, 300 feet below the canal river, then elevated to the line of the canal, and the sections set together. In spite of this method of work there has been no crack or break in the conduit since it was placed in service.

Remembering that the storing of the water and the spreading of it over the land by the government reclamation service is a scheme that affects no less than thirteen States of the West in addition to nearly all of the territories, an idea of the great importance of the projects may be gained since works are being constructed all the way from the Rio Grande river, forming a boundary between the United States and Mexico, into far away Washington. In some places the water is being stored in the gorges. In other spots it is necessary to form reservoirs in valleys of a formation through which the water would percolate, as in the case of the Carson Sink in Nevada. In other places rivers are being dammed where no masonry or other work of this kind can be utilized on account of the soft formation. Yet in every instance, without one exception, concrete has been necessary in many instances in place of stone or other material on account of its durability. Possibly, the most notable instance of its utility is in connection with the greatest irrigation project—The Roosevelt Dam in Arizona.

While the dam itself is being constructed of masonry, the blocks of stone are joined by a form of concrete made on the site of the present reservoir, in one of the largest works in the country, erected entirely for this purpose, and which will be abandoned when the project is completed. To operate the cement mill, to lift the blocks of stone into place, and to do other lifting and conveying a canal has been constructed which generates 4,000 electrical horse-power. All of this canal, which is 20 miles long and includes several tunnels through the mountains is concrete-lined.

So much has been heard about the expenditure by the government of money for irrigation purposes that private enterprise may have been overlooked. While about $50,000,000 have already been expended by the government, nearly as much is the amount of capital that has gone into irrigation schemes outside of the government work. Over 15,000,000 acres of waste land have already been converted into farms, reaching all the way from California northward to the State of Oregon, also on the west side of the Rocky Mountains. Here, again, however, concrete has been absolutely necessary in order to complete the various systems of storage and distribution controlled by the private enterprise.

SYNCHRONIZING ALTERNATORS

By S. G. Winn

THE synchronizing of alternators may be defined as the process of paralleling their armatures at the instant when their momentary pressures are equal in magnitude and sign and are increasing or decreasing at equal rates; in other words, when the voltages of the machines are equal and in the same phase.

Equality of voltage is easily determined, comparison of the voltmeters being all that is required. To equalize the phases, however, calls for special devices, such as synchronizers, the successful operation of which requires a certain amount of practical experience.

For the purpose of this article it will not be necessary to go into an elaborate description of the various synchronizers on the market (for they all more or less work on the same principle).

In Fig. 1, which shows the diagrammatic connection of an ordinary synchronizer, the generators are shown at Generator 1 and Generator 2. Generator 1 is on load, connected to the bus bars BB permanently on the earthed side and through a switch on the other side. Generator 2 is supposed to be running up to speed with its main switch open, except that it touches the synchronizing contact C.G.

The synchronizer consists of a small transformer S.P. wound with two separate and equal primaries, P^1 P^2 and one secondary S. P^1 is connected permanently on both sides to the bus bars. P^2 is connected to machine No. 2 by way of S.G. permanently on one side (the earthed side) and temporarily on the other side. The secondary circuit is closed, either with a lamp, a voltmeter, or both.

Now, suppose that Generator 2, although up to normal speed and pressure, is in opposite phase to Generator 1. The instantaneous magneto-motive forces in the two primary windings at any moment being equal and opposite, no magnetic flux will be produced to interlink with the secondary winding, and thus no electrical motor force will be generated in the secondary.

The lamp will, therefore, not glow, and the voltmeter needle will remain at zero. On the other hand, if the machines are in phase, the instantaneous magneto-motive forces in the two primary windings at any moment will be equal and in the same direction, and thus a strong magnetic flux will interlink with the secondary, causing the lamps to glow and the voltmeter needle to give a reading.

The approach to synchronous running is indicated by the flickering of the lamp or the oscillations of the voltmeter needle; the slower these become the nearer the machines are to synchronism. When the machines are very nearly synchronized some seconds may elapse between the successive swings of the needle from zero to a maximum. The reason can best be seen by a reference to Fig. 2. The speeds, and therefore the periodicities, are nearly but not quite equal. We may suppose that Generator 2 is running a little more slowly than Generator 1, so that the phases of the latter are slowly overtaking those of the former machine, the two coming into coincidence, say, every eight seconds. In Fig. 2 the continuous curve represents the volt-

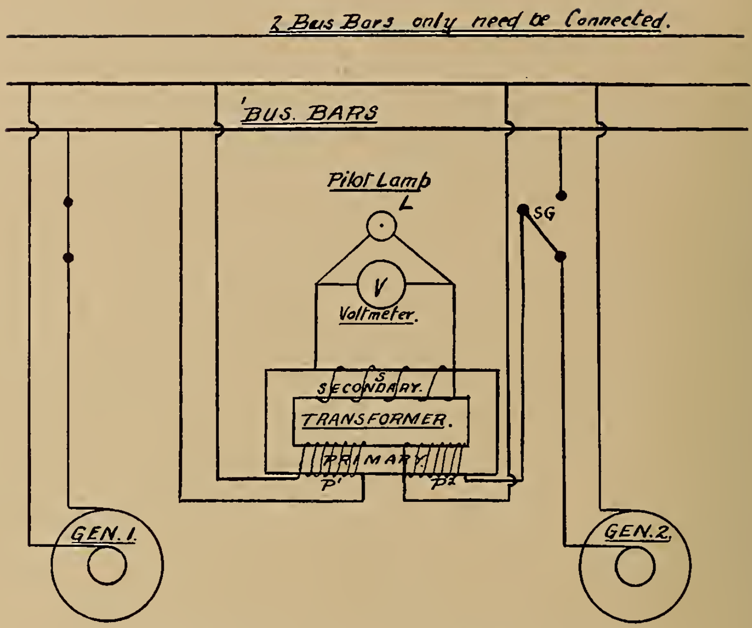


FIG. 1.—DIAGRAMMATIC CONNECTION OF ORDINARY SYNCHRONIZER

age of Generator 2, and the dotted curves represent the voltage of Generator 2 and the dotted curves those of Generator 1.

In diagram A the two phases are shown in direct opposition. Diagram B represents the state of affairs 1 second later; Generator 1 is now only 135 electrical degrees behind Generator 2.

During the next second the lag is reduced to 90 degrees, and then to 45 degrees. At the end of the fourth second the machines are in phase; and this is what happens when the deflection of the synchronizing voltmeter rises from zero to a maximum in four seconds.

The curves in Fig. 2 represent the pressures in the alternator armatures, but they may equally well stand for the magnetic-motive forces in the synchronizing transformer. It will be noticed that the two alternators are shown to be of equal frequencies. This cannot be the case, for the relative charge between the two phases is entirely the result of their difference in frequency. However, in such a case as this, where four seconds must elapse between zero and maximum potential on the voltmeter, the difference in frequency is so small as to be negligible on such a small sketch. It must, however, be remembered that there is a difference in frequency.

The magneto-motive forces in a synchronizing transformer, when the two primaries are fed with currents at widely different potentials and frequencies, may be represented by most interesting curves; indeed, this is the best way of understanding the actions that go on under such conditions. The curve of the bus bar voltage should be plotted, and on it should be superimposed another of different periodicity and pressure to represent the incoming machine; from this may be deduced a third or resultant curve that will explain the action of the voltmeter under any theoretical consideration.

In practice the speedy and satisfactory synchronizing of alternators depends to a very great extent on the skill of the man at the engine; he

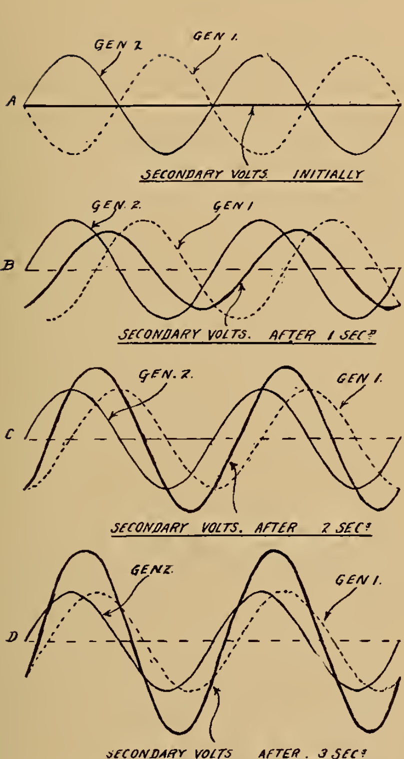
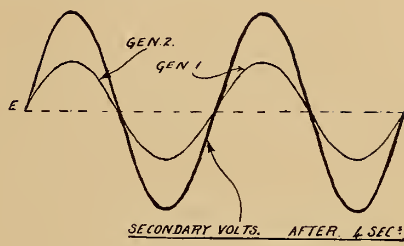


FIG. 2.—PRESSURES IN ALTERNATOR ARMATURES

should thoroughly understand his engine and know pretty clearly what will be the effect of any small variation on the stop valve.

The incoming machine is started and gradually increased in speed, the pilot lamp being watched the whole time. At first this will give a dull red light, the flicker taking place at such a rapid pace as to be quite undiscernible to the naked eye. As the speed increases the flicker becomes more evident, until when the speed is practically correct some seconds elapse between any two points of maximum brightness of the lamp. Now is the critical moment. The voltmeter needle creeps slowly from zero to maximum, and just before it reaches this latter point the switch is sharply closed. The alternators are now in parallel.

At first sight it seems as if the switch should be closed just when



the voltmeter indicates its maximum deflection. This is not so, for there is a certain time lag in the moving parts of the voltmeter (or, if the lamp is used, of the lamp filament) that makes it necessary to close the switch just before the point of maximum reading. The correct allowance can be found only by experience, for it will vary with the frequency of the alternations and the oscillation period of the needle. With the "hot wire" type of voltmeter as much as 8 per cent. must sometimes be allowed for.

It is important to remember that it is always better to close the switch too early than too late. In the first case the machines are coming into phase, and the "motor" currents set up in their armatures, due to the premature coupling, will tend to bring the machines into synchronism. On the other hand, if the switch is not closed until the machines have started to go out of phase, even although the angular displacement is the same as in the first case, the motor currents will be excessive and must exert enough force to wrench the machines into their right angular relationship against their own inertia and that of the prime mover. In the case of heavy plant the neglect of this point has been the cause of many a bad breakdown.

Another important consideration is to parallel the machines while the incoming machine is rising to synchronous speed. Although the indications of the voltmeter are the same whether the incoming set is rising or falling to synchronous speed, there is a difference in result in the two cases. If the speed is rising, the in-

ertia causes the machine to pick up a little load at the moment of paralleling, which acts usefully as a brake; but if falling, the inertia carries it still lower for an instant after paralleling, and the loaded machine is obliged to drive it as a motor in order to keep it in phase, unless more steam is given to the engine at once.

Here, again, the action is different in the two cases. In the first, simply a breaking effect is required, which at once produces synchronous running, but in the second there must be an accelerating effect, which means more power and larger motor currents from the already loaded machine.

The ideal conditions for synchronizing two alternators are, therefore, a steady and gradual increase in speed of the incoming machine and a phase on the voltmeter taking three or four seconds to reach its maximum. The switch is then closed shortly before the maximum is attained, and the result should be perfect paralleling with no noise or flicker.

The well-known optical effect produced by alternating arcs can be used as a help when synchronizing a machine. Consider the case of an alternator with rotating field magnets. If the light from an arc lamp is allowed to fall upon the particular alternator that supplies the current the poles will appear to stand still, the reason being that the light from the arc is not continuous, but fluctuates with the same frequency as the current producing it. At the instant of maximum light the poles are brightly illuminated and thus rendered visible. The light now dies down, and at its next maximum, the poles having now shifted forward one place, are seen as before.

Now, if the incoming machine is at a lower frequency than the one feeding the lamps the poles will appear to travel backwards; instead of moving forward one place per period of light fluctuation they advance rather less. In like manner, if the speed is higher, the poles will appear as if they were moving forward.

This method is an excellent guide to an engineman, for it tells him in a moment whether the incoming machine is running above or below synchronous speed. It does not tell him, however, when the alternators are in phase, and so cannot be used instead of a synchronizer. The synchronizer must still be used to tell when to close the paralleling switch.

In most cases the easiest way of getting the incoming machine to synchronize synchronous speed is by manipulating the main stop volve. If the sets are very large a bye-pass from the stop valve is very often fitted, and this can be used to advantage for synchronizing purposes. If there is no bye-pass and the main valve works stiffly, or is fitted with a coarse thread, partial opening or closing of drain cocks is occasionally resorted to in order to slightly alter the pressure in the cylinders. This cannot be recommended except as a makeshift; a bye-pass is far preferable.

Should the engine be off the valve and under the control of a governor of the variable expansion type slight differences of speed are often produced with difficulty, and here again synchronizing can best be done on the stop valve. If, however, the governor is of the throttling type very good adjustments can be produced by its aid, and then the stop valve need not be adjusted.

When the engine is brought up on the stop valve the latter should be opened up gradually directly the switch is opened, but if put in on the governor, self-regulation occurs to a great extent.

The actual operation of synchronizing is far more difficult than at first sight appears to be the case. The load may be constantly changing and with it the speed of the engines; very little change in speed makes a great difference on the synchronizer. A large load suddenly thrown on may convert a phase that gave every indication of being good into one

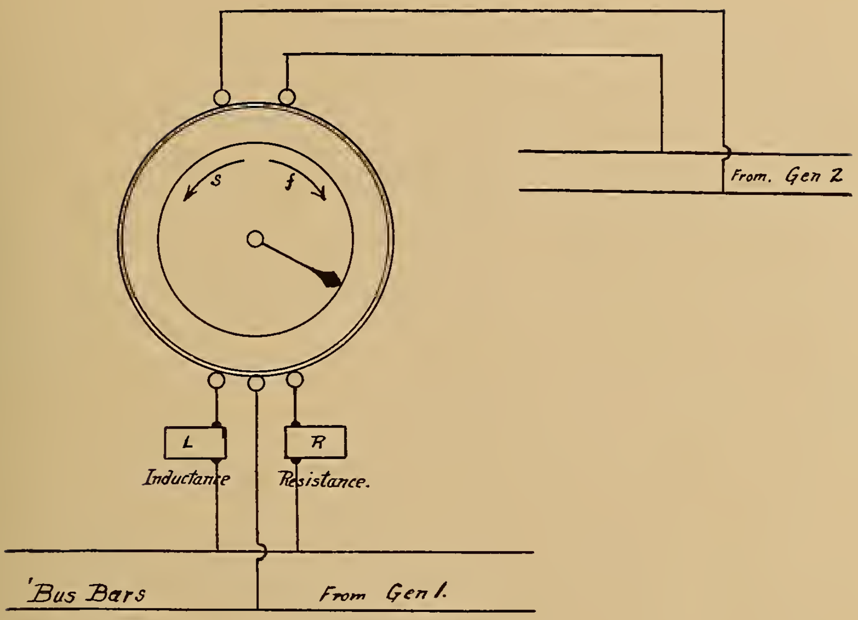


FIG. 3.—SYNCHRONISM INDICATOR

that starts to fall back just before it reaches its maximum. Such an occurrence must be carefully guarded against. Its prediction is purely a matter of experience, and, although an experienced man can generally tell when a phase is going to be a "short one," it would puzzle him to explain matters.

Such intuition, which is the essence of the art of synchronizing, can only be acquired by actual practice, though its acquisition may be largely helped by a good insight into the theoretical conditions that underlie the operation.

A MODERN SYNCHRONISM INDICATOR

During the last year or so many types of synchronizing indicators have been put on the market with the idea of making the operation of paralleling two alternators more simple. Some of these indicators are of an elaborate nature, whilst others are very simple. One of the latter, which works on the same principle as an alternating current motor, will be described.

The device as shown in Fig. 3 has the appearance of an ordinary switchboard instrument except that the pointer has no retaining spring or weight and is free to revolve through 360 degrees. When the speed of the alternator to be synchronized is too low the pointer revolves in one direction; if it is too high the pointer revolves in the opposite direction. When the speed is right the pointer is stationary; while when the speed is right, and the pointer indicates zero, the main switch may be closed and the alternators paralleled.

As indicated by the sketch Fig. 4, which refers to a single-phase installation, the indicator resembles an alternating current motor, the field being connected to the bus bars and the armature to the machine required to be synchronized. When the frequencies of the two machines are different the resultant field in the armature of the indicator constantly changes its position, making the armature revolve in one or other directions.

When the frequencies are the same the resultant field is stationary in space, and so the pointer connected to the armature does not move. When

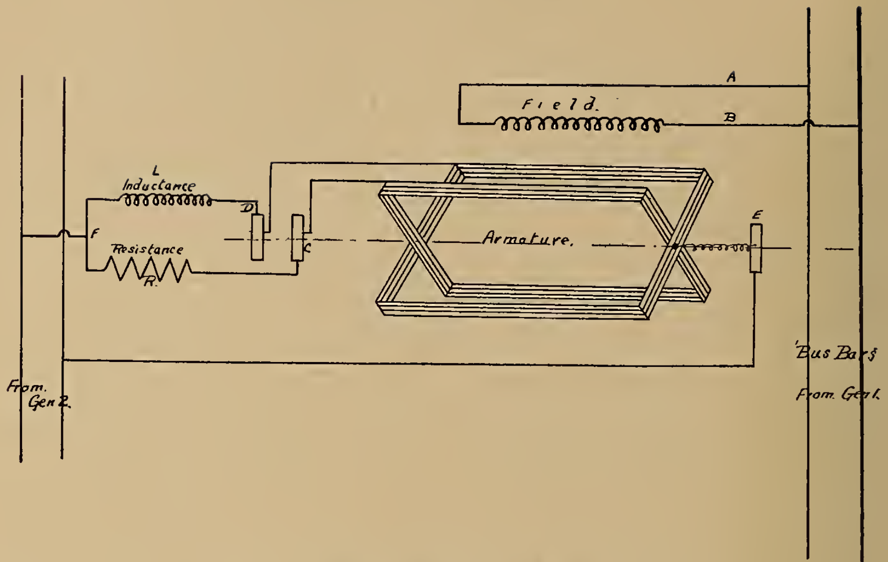


FIG. 4.—INTERNAL CONNECTIONS OF SYNCHRONIZER

the machines are in phase with one another the resultant field in the indicator is stationary and occupies such a position that the pointer connected to the armature indicates zero.

Referring to Fig. 4, the stationary field winding of the synchronism indicator is connected to the bus bars, that is, to the terminals of the Generator 1.

The revolving armature is connected to the machine to be paralleled through some inductance *L* and resistance *R*, the latter usually being an electric lamp The armature is of the drum type, having two coils wound in series and rigidly connected at right angles Their ends, as shown, are brought out to collector rings *D*, *C* and *E* The inductance and resistance *L* and *R* are used for "splitting" the phase of the armature current, so as to produce a revolving field similar to that in the case of a single phase induction motor.

Thus we have a stationary pulsating field produced by the already loaded Generator 1, and a revolving field (slit-phase arrangement) produced by the machine to be paralleled, Generator 2. If the frequencies of the two generators are not the same the two fields (revolving and pulsating) will not be in synchronism. There will consequently be an interaction exerted betwen the fields tending to bring them into synchronism.

As the armature is free to revolve, this will easily be brought about by a rotation of the armature at a speed varying with the difference of frequencies between the two machines. The more nearly the two machines approach synchronism the less is this difference, and the less is the speed of the armature. When they are actually in synchronism the armature will be stationary, for there will then be no interaction between the fields tending to cause rotation.

This does not infer, however, that the machines are in phase; only for one particular position of the armature is this so. Things must therefore be arranged so that when the armature is stationary the pointer points to the zero, this showing that the machines are not only in synchronism but also in phase.

It need hardly be stated that this zero position of the indicator is experimentally obtained in the testing department of the workshops before the indicator is put on the market.

No slit-phase arrangement is needed for a synchronism indicator when used on two or three-phase service. If a three-phase service, the phases are connected either directly or indirectly to the three slip rings, *D*, *C* and *E*. A revolving field is produced in the armature as in the single phase case, the machines being in synchronism and in phase when the armature is stationary and the pointer points to the zero position.

SYNCHRONIZING MOTOR GENERATOR SETS

Many alternating current systems include motor generator sets used in conjunction with batteries. In such cases the motor generators must again be synchronized. To do this the direct current machine is run up as a motor from the batteries, a resistance being inserted in series with its field. The field of the alternator is then switched on, rough voltage adjustment made, and the synchronizing apparatus connected in circuit. To increase the speed of the motor generator resistance is added to the motor field until synchronism is obtained. If a fine adjustment is required, and the resistance is found to give either too high or too low a speed, recourse may be had to slightly shifting the motor brushes. When the motor generator is in synchronism and phase the switch may be closed and the machine loaded on the direct current side. The field of the alternator should not, however, be excited until a speed near to synchronism is obtained, for otherwise a larger starting current will be required on the direct current side, owing to the eddy currents (and consequently opposing torque) that are set up in the rotating armature.

Motor generators, being light machines, require less care than heavy plant in synchronizing. They may be thrown in when a phase difference exists that, in the case of steam sets, would result in blown fuses. They have little inertia and can therefore be dragged into step very easily; for the same reason, however, they do not require much in the way of a sudden increase in load to cause them to break out of step.

Careless synchronizing, even in the case of motor generators, should be avoided as much as possible, for it sets up strains which ultimately have a bad effect.

In this article polyphase work has only lightly been touched upon, for the reason that the procedure is generally the same, synchronizing being carried out on one phase. High voltage systems, too, have not been mentioned. The procedure here is much the same, except that transformers have to be used in order to obtain low operating pressures.

SHEET STEEL PILING

By J. F. Springer

I.—DEVELOPMENT OF EARLY METHODS

In the present article Mr. Springer discusses the development of sheet piling for the construction of foundations in connection with the demands of conditions in quicksand, loose earth, and water; passing through the uses of timber, cast iron, and the earlier forms of sheet metal interlocking piles, and covering practice in Europe and America. The second article will describe very fully the most modern types of sheet-steel piling, with numerous illustrations of the different types, methods of driving, and possibilities of use. Both articles thus cover the development of the subject in its entirety.—The Editor.

To build upon the solid rock is, no doubt, a constructional ideal. But it is often difficult of attainment. The rock upon which we seek to lay our foundation-wall or pier may be many feet below the surface directly accessible, and the intervening material may be difficult. This difficulty may relate not so much to removal of the material excavated, as to the control of that portion that is left behind. Thus, this material may be a quicksand, when the problem is not so much how one is to excavate, but how one is to maintain the non-excavated sand *in statu quo*. Or, the intervening material may be only water, when precisely the same difficulty comes to the fore. Or, the problem may assume the form presented when the strata themselves have no inclination to flow, or otherwise change the positions of their parts, but contain practically an inexhaustible supply of water.

To meet such difficulties as those referred to, sheet-piling was invented. I had written "had been invented," but this would give an erroneous view of the origin of the sheet-pile. That origin is certainly not connected with the present. The problem of maintaining the banks of a ditch is too old for simple and effective solution through the instrumentality of the sheet-pile to have had its origin within the limits of that which we ordinarily call history. Indeed, necessity must have mothered this invention many times afresh during the historic ages. The earliest sheet-pile was, without doubt, an unhewn timber. And it deserves the adjective "sheet," in spite of the want of flatness in the individual. The wall of upright timbers constituted a sheet of material as much as the thinnest of the most modern forms. With an unrecorded history reaching back beyond, no doubt, any possible research, the sheet-pile never seems to have passed through any especial development. The squared timber was employed. Such devices as the tongue-and-groove arrangement have been used—and with considerable success. Perhaps the very highest type of wooden sheet-pile is the Wakefield sheeting, which was invented and patented in the latter part of the nineteenth century. In Fig. 1, we have shown, in cross-section, three such piles assembled. Each consists of three planks identical in width and thickness. These are bolted and nailed together to form a unit-pile, having a face equal to that of a single plank and a tongue and groove of the depth of one-half the width of a plank. Driven in the manner indicated in the figure, this style of sheeting has been fairly successful. An improvement that the writer ventures to suggest is indicated in Fig. 2. The central plank, while kept of the same thickness as the others, is narrower. Placed so as to form a tongue of one-half its own width, it will form a pile that, when a number

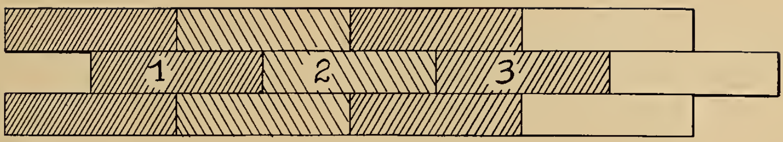


FIG. 1.—WAKEFIELD WOODEN SHEET PILING

are assembled, the tongue will fall short of completely filling the groove. If the piles are intended for temporary construction, the open spaces thus left may be filled with clay and so rendered water-tight. If the construction is permanent, the clay may be replaced by concrete or cement grout. Another type of wood pile is that shown, in cross-section, in Fig. 3. Here all the piles are double-grooved, the tongue being a separate piece of wood. If one uses such piles they should not be driven, it would seem, until the tongue has been inserted in one of the piles. Otherwise, the pile, being driven, would be insufficiently guided —unless conditions are quite simple or other precautions extraordinary—and the success of subsequently driving in the tongue would become doubtful. The simplicity and accuracy with which the Wakefield wooden pile may be fabricated, together with the strength of the finished product, command this type where wooden sheeting seems advisable.

It requires but little thought to convince one that sheeting — whether wooden or not — will often have to withstand enormous pressures. Thus, the wall of piling may have the duty of retaining a pocket of quicksand, which, in turn, may be supporting not only its own weight but some other and tremendous weight of overlying material. The sheet of piles will have to be of very considerable strength or be very securely braced to withstand the great horizontal thrusts developed out of such conditions. That the engineer must frequently have to deal with terrific forces operating against his piling is well illustrated in connection with the great disaster at Newport, England. At this point in the Bristol Channel, a very large lock—1,000 ft. × 100 ft.—is in course of construction. Two wing-walls are to form part of the entrance to this lock from the Channel-side and to form retaining-walls for the protection of adjoining embankments. As a temporary protection during construction, an embankment was thrown across the foreshore. The problem of securing an adequate foundation for the walls was found very difficult. This was largely due to the treacherous character of the considerable stratum of mud overlying a deposit of sandy gravel and silt. Below is a hard marl upon which all foundations are to be laid. The temporary embankment has not proved water-tight, but, perhaps, this circumstance has played no considerable part in the disastrous results. However, to reach the marl and lay the foundations open trench-work was decided upon. Upon July 2, 1909, the trench

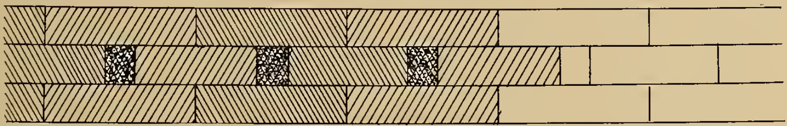


FIG. 2.—IMPROVEMENT ON WAKEFIELD SHEET PILING

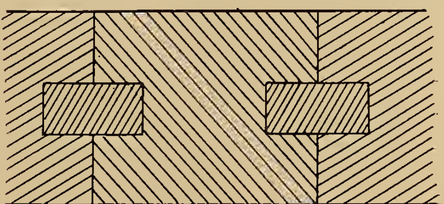


FIG. 3.—DOUBLE-GROOVED SHEET PILING

for one of the wing-walls had been excavated to its full depth and the difficult strata were being withheld by a very stout wall of wooden sheet-piles. The timbers entering into this construction consisted of pitch pine baulks, 13″ × 13″ and 14″ × 14″ in cross-section. The struts were only a little lighter and were, apparently, used with liberality. However, this trench was fifty or more feet deep. When all was ready to begin with the concreting, suddenly, and without warning, the protective system of piles and struts gave way. And so quickly did the disaster become approximately complete, less than half the workmen escaped. The trench had been kept clear of water by a pumping-plant, which was destroyed in the common ruin. Some of the men were, no doubt, only imprisoned. But the failure of the pumping system sealed the doom of all not liberated, with but little delay, by permitting submergence.

It is such cases as this that impress the engineer with the need for strength in his sheet-piles. It is, perhaps, true that the Newport disaster was largely due to conditions that mere strength of the sheeting would have been ineffectual in meeting. At the same time, the question of strength must have been a large—even if we grant that it was not a controlling—factor.

It would be much more practical, there can scarcely be any doubt, to secure enormous strength of wall with steel sheeting than with wooden. Weight for weight, the steel is much the stronger. Then, too, it may be put into a form that enables its resistance to a lateral thrust to be much augmented without any increase in weight. This management of form is next to impossible with wooden piling. Of course, no style of sheeting would have been effective in taking care of an upward thrust, as seems to have occurred at Newport. This, however, is not its office. It is the duty of sheet-piling to withstand lateral pressure. And there can be no question that this can be more effectively performed by steel than by wood.

But there is a further marked ineffectiveness in the wooden sheet-pile. This is in respect to the nature of the interlock. We may picture the wooden lengths all driven home in precisely the position desired, with all tongues in their grooves—the whole forming a continuous wall. But, while we may grant the continuity of the wall on the day when the work is complete, we may well raise the question whether that continuity may be expected to continue. This will depend upon surrounding conditions. If, however, the sheeting is to be subjected to a lateral, unbalanced thrust, we may inquire whether the interlock should not assist in the prevention of a disruption of the surface. With such interlocks as those shown in Figs. 1, 2 and 3, there is little or no resistance to such a thrust, if it extends from top to bottom of a part of the sheeting, or if it is especially strong for a less vertical distance. It seems impractical to construct the wooden sheet-pile as to make the interlock an effective participator in resistance to severe unbalanced thrusts. But this may be done, and is, in fact, being done with steel forms.

A further problem encountered with the use of wooden sheeting consists in the difficulty of driving it through hard soils. The blows, required frequently, become so severe that the pile is split or it is splintered at the foot. Now, steel-sheeting may be so made that when further penetration has really become an impossibility, the impacts of the driving hammer are spent in merely upsetting the metal on the ends of the pile.

However, the facts that the wood sheet-pile is readily fabricated, and that the material is often close at hand, are considerations that will probably prevent it from being entirely superseded. At the same time, its deficiencies are so patent that as early as the first quarter of the nineteenth century a style of cast-iron sheet-pile was invented and used in England. The first patent seems to have been that issued

FIG. 4.—THE EWART CAST SHEET PILE

to Mr. Peter Ewart, 1822, by the British government. But he was anticipated by Mr. Mathews, who had actually used iron sheet-piles previous to the date of the patent. The form of what thus appears to have been the first metallic sheet-pile is given in Fig. 4, in cross-section. These piles were employed by Mr. Mathews in the construction of the foundations of the north pier of Bridlington Harbor. However, more than one style was

FIG. 5.—EWART LOCKED PILE

employed. In other forms used it seems that there was not the real interlock shown in this figure — only an overlap. These pioneer iron piles were not very long, being only about eight or nine feet in length, as we are informed by Mr. M. A. Borthwick. They were one-half inch thick and about two feet — or somewhat less — in width. In spite of their inconsiderable length, these sheet-piles have a historic interest.

But the first patentee seems, as already noted, to have been Ewart. To him much credit is to be given because of the educating influence he exerted in relation to the actual introduction of his system of piling. In Fig. 5, we have a cross-sectional view of two of Ewart's piles as shown in his patent. In Fig. 6, we have the same type of pile, slightly modified. This last is said to represent some piles actually used. In Fig. 7, we have still another form. It was not long after the issuance of the patent that some extensive applications were made in works at London and Liverpool. At London, for instance, they were employed in a large coffer-dam in the Thames, constructed with the object of laying a suction-pipe. At Liverpool they were

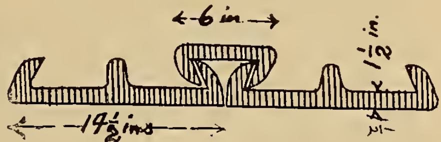


FIG. 6.—A FORM OF EWART PILE

found serviceable in pier-work. Some difficulty was experienced at Liverpool in driving the piling vertically. Some further difficulty arose, apparently, from the line of fall of the hammer being out of alignment with the axis of the pile when driving into heavy soil. But, after all was said and done, they were highly appreciated by the engineer in charge. A novel method was followed at London when forming a coffer-dam. This was to arrange the piles in their proper positions, driving them in but slightly. The pile driver then went round and round the work, sending each pile down a little upon each trip.

In 1824, as Mr. Borthwick tells us, the Ewart sheet-pile was again used. The application here was in the foundation-wall connected with Downes Wharf, St. Katherine's. This is probably the first instance where metallic sheet-piling was used in permanent work. In this construction the form of pile was modified soon after beginning. The form actually used for the bulk of the work is shown, in cross-section, in Fig. 8. Comparing this view with that shown in Fig. 7, we see that the modification consists mostly in a simplification of the interlock or

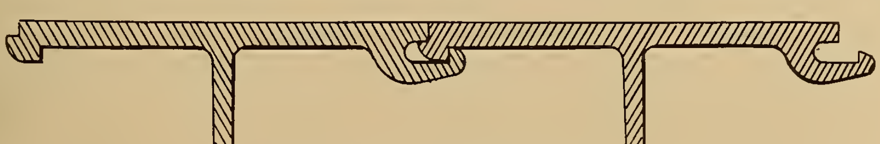


FIG. 7.—EWART INTERLOCKING PILES

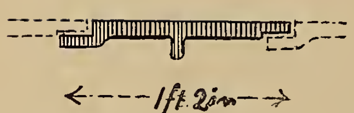


FIG. 8.—EWART CAST PILE

joint. The interlocks shown in the Ewart piles of Figs. 6 and 7 are such in the modern sense. They permit the piles to be separated in no direction except a vertical one. However, it was found difficult to drive them in line if the original form was used, on account of the depth and hardness of the soil to be penetrated. It will be noticed that the reinforcing rib was considerably diminished. This rib, when the pile was in place, was on the outside. The piles used in this permanent construction were 14 feet long, and were driven nearly their entire length.

In Mr. Ewart's specification—1822—he provides for a difficulty he seems to have anticipated might occur. In order to take care of any possible expansion and contraction of a coffer-dam wall constructed with his piling, he devised a special form of pile that could be used at intervals. This loop form of pile is shown, in cross-section, in Fig. 9. The writer is not aware, however, that this precautionary device was ever found necessary in any of the

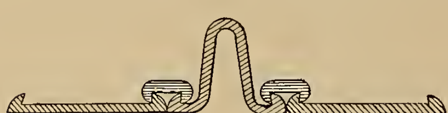


FIG. 9.—THE EWART EXPANSION JOINT

numerous applications of Ewart's piles.

But in 1832 was completed a work in which cast-iron sheet-piling found its first extensive application. The linear extent of sheet-pile wharfing, constructed at the sea-entrance of the Norwich and Lowestoft navigation, on the east coast of England, was about 2,000 feet. The piles used were 30 feet in length, and weighed about 3,300 pounds each. The form used is conspicuous for the depth of flange.

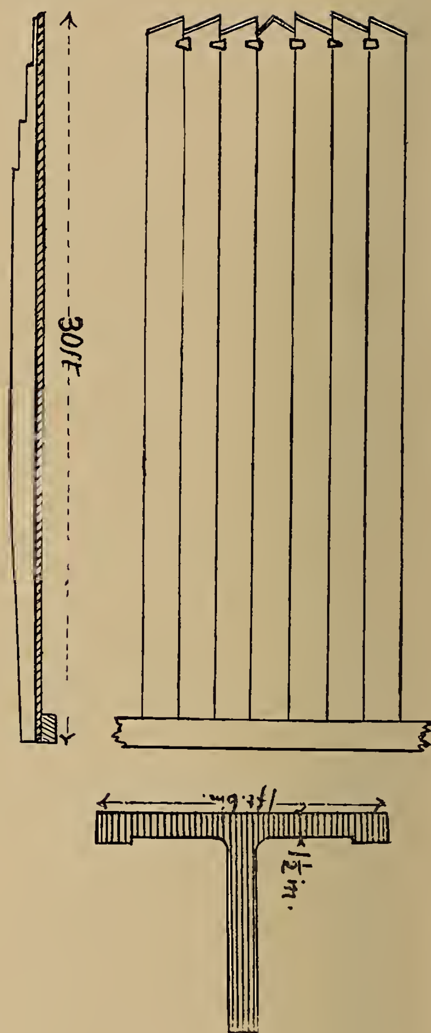


FIG. 10.—CAST IRON PILING AT LOWESTOFT

In Fig. 10, we have, at the top, a view of a cross-section about the middle of the length. The flange was reduced to about 6 inches at the top, where the angles between flange and pile were blocked-in to form a suitable head to receive the impacts of the pile-driver. At the bottom, the flange was reduced to almost nothing at the point by a stepped construction. See Fig. 10. This last seems a very wise provision, as, thus, no taper was formed to wedge the pile out of the vertical. These piles were driven with the flanges at the back. It will be noticed

FIG. 11.—SHEET PILING CONSTRUCTION AT BRUNSWICK WHARF

that the idea of Mr. Ewart and Mr. Mathew of an interlocking relation, secured by the form of the piles themselves, is here dispensed with. However, some system of keeping the piles longitudinally in contact was necessary, and this was provided by means of a clasp or clip of wrought-iron riveted at the bottom and on one side of the pile to be driven. This engaged the pile already in place, and so prevented a forward or backward displacement. Separation laterally was avoided by giving the bottom an inclination toward the pile in place. The driving operation would then tend to wedge the new pile against the old. This wall of iron sheeting was secured to the bank by land-ties.

An important application of cast-iron sheeting was made about 1834, in the construction of Brunswick Wharf, on the Thames. While the linear extent of this work was only about 720 feet, and so renders it scarcely comparable with that last described, it is, yet, of importance as corroborating the evidence supplied by that work for the continuance of confidence in the use of cast-iron sheet-piles in permanent work. In Fig. 11 is a view of a front elevation of a portion of this wharf. It will be noted that the piles are of two kinds. There are the main piles, arranged with an interval of about seven feet between centers. A series of sheet-piles fill up the intervening space. These sheet-piles resemble those used at Downes Wharf. However, there are two reinforcing ribs, and these are placed to the rear. The overlap is omitted in that pile where it would otherwise conflict with the main pile adjoining. In driving these piles through the coarse gravel and an occasional layer of hard Blackwall rock, no great trouble was experienced in keeping them in line and filling the spaces left between the main piles that were driven first. Only a

few special piles were necessary to effect the closure of the bays. The main piles, because of transportation reasons arising out of their weight and length, were cast in two pieces. The sheet-piles were about 22 feet long; the main piles about 37½ feet, the lower portion being about 25½ feet. The web of the sheet-piling averaged about 1⅛ inches in thickness. The weight of such a sheet-pile was about a short ton. Approximately 600 piles —about 500, apparently, being sheet-piles—were driven. Of this number only sixteen were broken in the driving operation. And it was thought that imperfect casting was responsible for eleven of these. The cost of the piling was about $35.00 per ton, delivered. By examining the front elevation, shown in Fig. 11, it will be seen that plates were used to close the bays between the main piles above the heads of the sheet-piles.

Cast-iron sheeting seems to have had its principal application in England. There it was, apparently, first invented and first used. The writer knows of few or no cases outside of England or English dependencies where it has been employed. That such piling still retains the favor of the English engineer is witnessed by two recent applications of it to permanent construction in Egypt. As is well-known, the Nile is approximately the only source from which this fertile land draws its water-supply. The yearly volume is enormous, but this would be partly wasted if artificial means were not employed for its conservation and distribution. The great Assuan Dam, in Upper Egypt, is a recent example of the construction necessary to effect these objects.

Other irrigation works are the canals that carry off water from the Nile and distribute it over a wider expanse than would otherwise be possible. One of the most important of these distributing streams is the Ibrahimia Canal, which branches off from the Nile about 340 miles, downstream, from the Assuan Dam. This canal is, of course, entirely dependent upon the great river for its supply of water. In fact, its usefulness to the adjacent country is dependent upon the water-level of the Nile. When the Nile is flooded, there is plenty of water. But when there is low Nile, it has been found difficult to effect an adequate distribution. Consequently, it has long been desired to secure in summer a higher level of the river at the point where discharge is made into the canal. It was deemed inadvisable to construct a solid dam across the river, on account of the level that would, thus, have been produced during the flood season. And so it was decided to build across the river an arched viaduct on a masonry floor. The point near Asyût, selected for this barrage, is where the river straightens out below the place of origin of the Ibrahimia Canal. Here the width of the Nile is somewhat over half a mile. The bottom was found to be subject to violent fluctuations in depth. At first, it was expected that the masonry floor could be laid at different levels, but, upon the discovery of the changes taking place in the bed, it was decided to adopt a single level. We are particularly concerned with the foundation for this floor, for it was in connection with it that the cast-iron sheeting was employed. The present example is important, not so much on account of the particular material used in the piles, but for two other reasons. First—the employment of metallic piling in a large and important engineering work; and second—the significant fact that the original plan of sinking rectangular wells to form the main portions of the up-stream and down-stream curtain walls was abandoned and the curtain walls actually constructed of metallic sheeting. The fact that these sheet-piles were of cast iron, and not of steel, need not trouble us. If cast iron is a suitable material, then all the more so is this the case with steel. So that this example may very properly be cited in support of the use of steel-sheeting in permanent aqueous construction. The floor was built about 87 feet wide and nearly 10

feet thick. It consisted in the main of a lower stratum of concrete about a yard thick, overlaid by rubble masonry. The cast-iron sheeting was driven so as to form a curtain wall on both the up-stream and down-stream sides, reaching 13 feet below the floor. The heads of the piles were made flush with the upper surface of the concrete in the floor. Suitable aprons were constructed on each side. These were about 65 feet broad. As the floor was constructed during the first season, the curtain walls of iron piles formed the lateral boundaries of the concrete in the floor.

About 3,000 tons of iron sheeting were used in connection with the barrage alone. Another 1,000 tons were consumed in the regulator for the Ibrahimia Canal. This work was a barrage of the same general character as that across the Nile. Both constructions, including their locks, were completed in 1902.

A similar work, both as to general design and mode of construction, is the Zifta Barrage in the delta region of the Nile. The same style of cast-iron sheeting was employed to form an upstream and a down-stream curtain-wall. It is, perhaps, worthy of note that, to secure a water-tight joint between the concrete floor and the piling, each layer of concrete was removed to the depth of four inches along the line of junction and the space filled with neat cement. This construction was completed in 1903.

From these instances of the Asyût and Zifta barrages, both completed only a few years ago, it will be seen that the history of the cast-iron pile must have been a very favorable one to have induced English engineers, after eighty years' experience, to adopt it for permanent work in two such important constructions. And all that can be said in favor of the cast-iron sheet-pile may be repeated with respect to the steel-pile. Much more of advantage, also, may be added. It is difficult to understand why the engineers in charge of these Egyp-

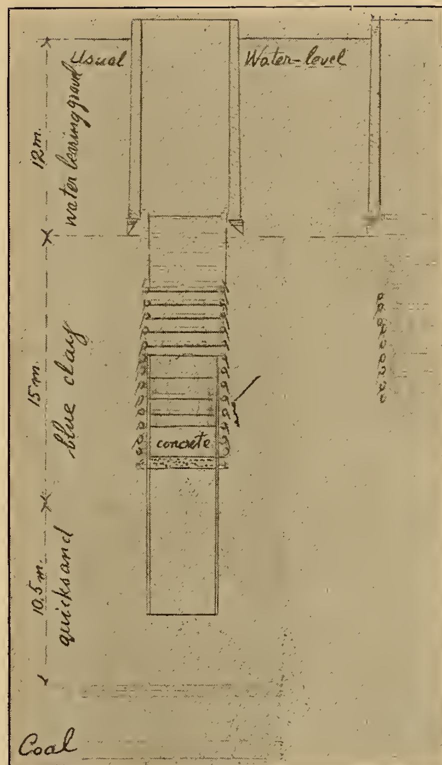


FIG. 12.—SHAFT SINKING AT THE NEW HOPE MINE

tian works should have selected cast-iron when they might have had steel. Nevertheless, they used the cast-iron sheeting, and, apparently, with success. So that with better material and a better design, the recent types of steel sheet-piles, it may well be claimed, promise a great deal to the engineer.

STEEL SHEET-PILING

Perhaps the very earliest employment of steel-sheeting was when the Germans, about two decades ago, made use of it under trying circumstances. At the New Hope Mines, in the Magdeburg mining district, a shaft was being sunk to the coal-seam 125 feet below the surface. As shown, in Fig. 12, there was to be penetrated, first of all, a considerable deposit of gravel, 39 feet in thickness. The water-level in this was close to the surface. Below the gravel was a thick stratum, 49 feet,

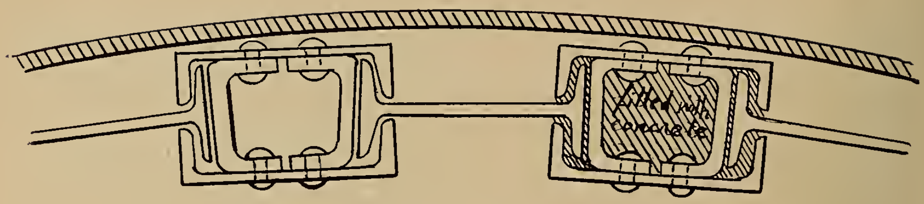


FIG. 13.—THE HAAS PILING FOR MINE SHAFT

of blue clay. This was underlaid by 34 feet of quicksand. The remaining 3 feet or so were principally occupied by a layer of clay. A masonry cylinder, properly shod with a cutting edge, was started down. When this was about to penetrate the blue clay and thus shut off the water from the gravel, it stuck. It became necessary to shut off the water. This was accomplished and further penetration secured by the use of timber-sheeting. The room required for this and its bracing reduced the cross-section of the shaft. This would have been of no especial importance, perhaps, had it not been for the trouble occasioned later by the quicksand. Timbering was carried down through the clay until only about 6 feet more remained. It was expected to penetrate the quicksand by means of the Haas system of tubular-sheeting. A plug of concrete, 5 feet thick, was laid on the floor of the shaft, and on this a 13-foot section of tubing was set up. This plug was to restrain the quicksand, which had broken through from below. The tube was put down through the concrete by means of cutting devices attached to them. But scarcely was this accomplished when the quicksand reasserted its presence: and that in spite of a 6-foot layer of gravel adding its weight to that of the concrete. It seems that this weight of gravel could not be increased, because the tube could not be extended upward on account of interference by the timber water-curtain. The endeavor was now made to carry the tubing downward by hydraulic pressure, working from a point about 60 feet below the surface. This proceeded successfully, in spite of the uprising quicksand, until a depth of 107 feet was reached. But, surrounding buildings had now manifested settlement; the masonry wall at the upper part of the shaft was cracking. With the water coming in from above, and the quicksand from below, was every expectation that a collapse of the work would be precipitated by an attempt to persist in the present procedure. Still there was a distance of about 4 or 5 yards to penetrate to the impervious stratum overlying the coal. Things were in a critical condition. Something had to be done, and something different, apparently, from what had been tried. The quicksand could, without doubt, be overcome, if only a sufficient weight of gravel were imposed.

Out of this necessity, one of the most successful forms of steel sheet-piling was born. The manager of the mines, a Mr. Simon, influenced, as it seems, by the Haas system of tubing, devised the pile shown in cross-section in Fig. 13. The elements of this sheeting were things at hand, or easily gotten. Two channels entered into the construction of what may be termed a main pile; an I-beam constituted the sheet-pile proper. The manner of constructing the main pile was to arrange the channels immovable face to face and in such position as to permit the interlocking of an I-beam at each side of the box-like structure formed. In the present case, five pairs of separators were distributed along the length of a main pile and securely riveted to the two channels. The sectional form and arrangement of these separators will be understood from the figure. It will be noted that the interior of the box-like piles permitted filling with

concrete. It is important to observe two things. First, the interlock is extremely effective. Sheeting once in place becomes to all intents and purposes a single piece of metal. Second, it is possible to make the piling water-tight.

The shaft was filled with gravel well up to the lower part of the masonry cylinder. The pieces of piling were properly assembled with the aid of four rings, arranged on the inside of the cylindrical wall of sheeting. Later, these assisted also in keeping the piling in place during the driving. It was necessary to proceed cautiously, as it was not deemed advisable to attempt to remove the timbering all at once. So, section by section, as it were, the planks were withdrawn and the steel piles well driven down into the blue clay. Upon being driven in, the wall of steel was made water-tight with concrete. Water, however, rose out of the joint between the stone cylinder and the piles. This finally was cut off by permitting the water to come in and rise to its full level, then filling the space between stone and steel with cement-mortar. The deposition of this concrete was accomplished from the surface by means of tubes. In two weeks, the water was pumped off and the joint found to be successful. In short, it now became possible, as Herr Schmeisser informs us, to extend the Haas tube upward. This permitted the use of more gravel, to overcome the upward pressure of the quicksand, and the elevation of the working point from which to proceed with the putting down of the tube through the stratum of quicksand.

By referring to Fig. 12—right-hand view—the steel-piling may be seen in place, extending some four or five yards from a point about the foot of the stone cylinder. The left-hand view shows the piling part way down. In Fig. 13 we have a fragmentary horizontal section.

THE STEEL SHEET-PILE IN ENGLAND

The use of steel-sheeting by British engineers has scarcely been common enough to justify the assumption of a well-settled practice. However, there has been at least one large construction in England where steel sheet-piles were extensively used, besides one or two minor instances of their application. But we may be sure that the nation that recognized the advantages of iron-sheeting will very extensively employ steel-piles now that their introduction has begun. Let us consider, in detail, what seems to be the first large use of steel sheet-piling in England.

THE OUTER BARRIER OF THE HODBARROW IRON MINES

The Hodbarrow Iron Mines are situated at the southernmost end of the peninsula in which the county of Cumberland terminates. For many years mining in this vicinity has been carried on. In 1868, as Mr. H. S. Bidwell tells us, a large body of ore was discovered. This deposit, beginning at a point back from the sea, extends seaward and downward. The dip is, however, slight. In carrying on operations for the excavation of the ore, some protection against the sea became necessary, because of the insignificant height of the natural sandbanks along the shore. And so in the early eighties a timber revetment was constructed of wooden sheet-piles. The main piles, of 12 × 12 timbers, were placed about 20 feet apart. Between these the 6-inch sheeting proper was driven into an average depth of about 7 feet. There were wales in front of this wooden wall. The main piles were land-tied to other piles 60 feet distant. But, construction was scarcely completed when the work was severely damaged. Knowing that ore existed seaward, and, believing that a more substantial barrier was necessary to prevent serious loss from the efforts of the sea, the mining company proceeded to build a wall further out. This was a concrete wall protected by a rear-embankment of clay and by a curtain-wall and trench of the same material extending into an underlying clay-stratum. That these provisions were, unfortunately, scarcely

adequate was proved when a bed of quicksand was uncovered within the working years later. A portion of the work subsided, owing to the resultant undermining far below the curtain-wall. However, certainty as to the existence of a large body of ore, extending seaward, was furnished by the results of boring operations. It was resolved, in view of all the facts, to build a third sea-defense in the form of an arc, and of such size and so disposed as to safeguard the operations necessary to the recovery of the ore now known to exist beneath the foreshore. The magnitude of this Outer Barrier may be understood when it is said it is over a mile and a quarter long, has a maximum height of 40 feet, and a maximum basal width of 210 feet. The land inclosed and thus reclaimed is about 170 acres. For the larger part of the four and one-half years that construction was going on, 1,200 men were employed. Expenditures amounted to £560,000. In view of the size of the undertaking, the professional standing of the engineers who were more or less in contact with the work, and, finally, of the previous experience of the company with sea-defenses, we may safely conclude that this structure is a fair representative of the best engineering of the kind in England. That steel-sheeting here was used in permanent work, not only extensively but more extensively than originally planned, may be taken as a very strong indication that the steel sheet-pile has come to stay.

The barrier consists essentially of an outer and an inner limestone-bank with an intermediate filling of clay. The outer embankment, which is, of course, much the more massive of the two, is protected for nearly a quarter-mile from each end on this seaward side by large pieces of limestone. The protection of the long central section is afforded chiefly by heavy blocks of concrete deposited irregularly but not pell-mell. There is a core of puddled clay imbedded in the clay-filling between the limestone-banks. A curtain-wall extends beneath this trench to impervious material, or, where that is too far down, for a considerable distance. This curtain, it was decided, at first, should consist, with the exception of the 33.5 linear feet of the concrete foundation of the sluice-culverts, of puddled trench, pitch pine sheet-piling and steel sheet-piling. Of the total of 6,870 linear feet of curtain, the trench was to be employed for 3,750.5 feet, or considerably more than one-half the distance; the pitch pine sheet-piling was to be used for 1,390 feet; and the steel sheet-piling for the 1,696 feet. When actual construction took place, the distribution was quite different. The puddled trench lost enormously, being reduced to 1,040 feet—less than one-third the original length; the pitch pine sheet-piling gained from the trench, but lost more heavily to the steel-sheeting, concluding with 1,200 feet net; while the steel sheet-piling increased to 4,630 feet, not counting auxiliary sheet-piles used. The steel-sheeting actually used was 67 per cent. of the total, whereas the amount contemplated had been scarcely 25 per cent.; the steel lost to neither of the others. On the contrary, it gained from each, being substituted both for the puddled trench and wooden sheeting. In addition, steel sheeting in two lines were used across and beneath the culvert location. The significance of all this is emphasized when we remember we are dealing with permanent construction alone. A further deepening of the emphasis is made when we consider that corrosion is a factor to be taken into account.

In view of the substitution of steel sheeting for wooden piling and puddled trench, a word as to the character of the two latter will be in place. The wooden sheeting consisted of timbers, 12 × 12 inches or more in cross-section, the length varying from 18 feet to 27 feet. Grooves 3¾ × 1⅞ inches were cut to accommodate tongues 3½ × 3½ inches. These piles had a 4-foot penetration into clay at the bottom. The tops were 3 feet above the ground. A heavy waling, 12 × 6 inches in cross-section, was bolted to

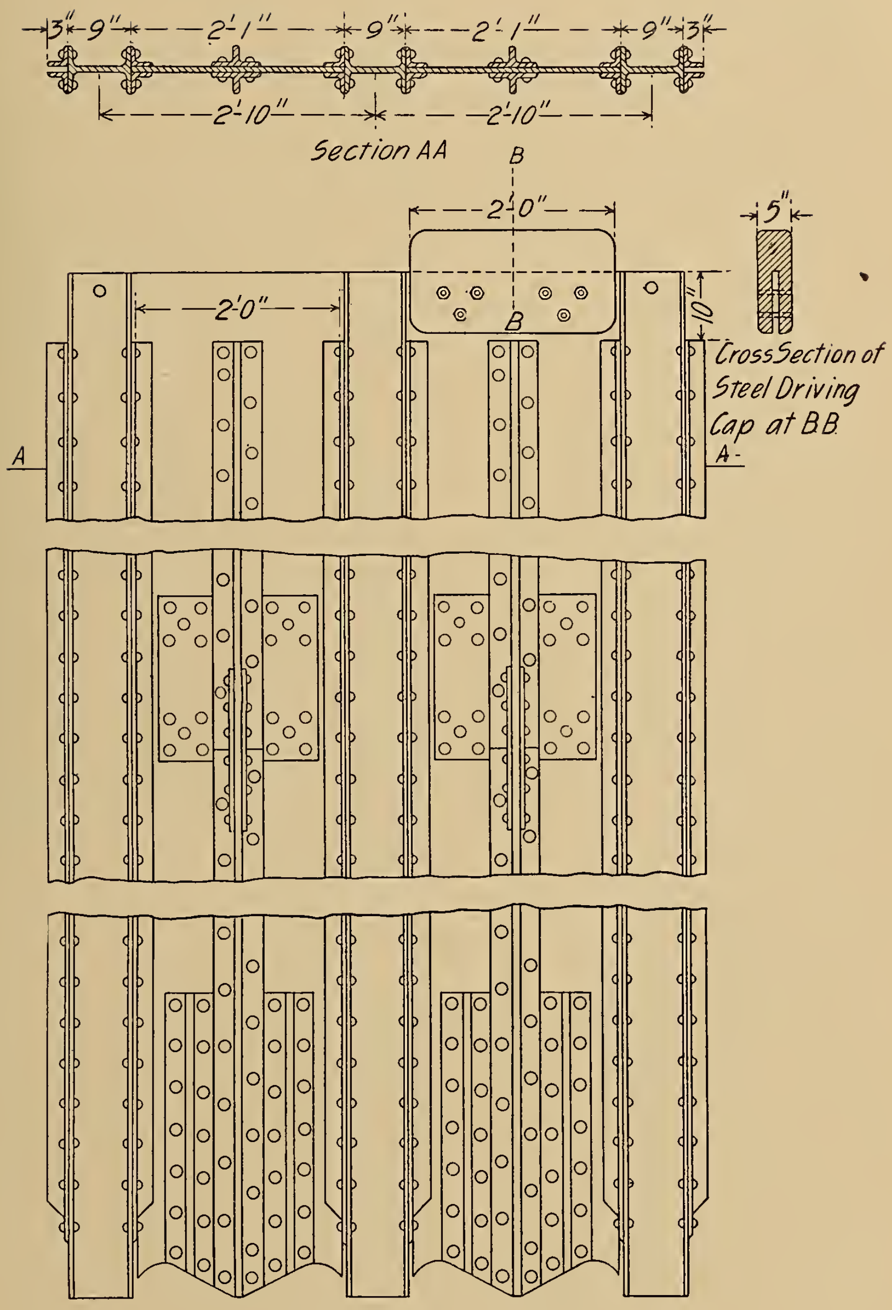


FIG. 14.—SHEET PILING USED AT THE HODBARROW MINE

the piles on the inner faces. It will be seen from the foregoing details that the wooden sheeting was of a very substantial type. The trench used was ordinarily 7 feet wide and was keyed into rock or clay to a substantial depth. The principal reasons for the substitution of steel sheeting are instructive. (1) Attempts to drive the wooden piles when a point about 2,400 feet from the west end proved unsuccessful. The ground was very hard indeed. Certain of the wooden piles, upon being withdrawn after having refused to pentrate further, were found to have "their ends burred into fibre." (2) The upper surface of the material into which it was necessary to key the trench was found to be much more irregular than the preliminary borings had indicated. Thus a dip of 4 feet would be encountered at one place between the front and back; at another spot, there would be a dip along the line of the work of 45 degrees. It had been intended to use the trench at each end and at the center. Steel sheeting was substituted at this center, and for more than half of one end the total substitution of steel for clay being 2,360.5 feet. We have, then, these facts: If the wood could not be driven the steel could; and if the trench could not find a suitable footing the steel could. This ability of steel sheeting to meet varying and exacting requirements is one of its chief advantages.

In Fig. 14 is shown in cross-section the system of steel sheet-piling actually employed. This, however, was not adopted until after experimentation with a somewhat similar style.

The forms and arrangement, substantially as in Fig. 14, were then devised and a trial bay, consisting of three main piles and two intervening sheet-piles, was driven and examined to a depth of 29 feet. This examination disclosed a slight bulging. No interlock was broken up. Testing for the percolation of sea-water disclosed that, if there was any at all, it must have been negligible. It will be understood, upon comparing the successful and unsuccessful bays, that the chief difference consists in a marked increase in the stiffness of the sheeting as a whole. While, no doubt, the main piles of the successful bay are the stronger, the reinforcement is, on the whole, uniformly distributed. The I-beams in the sheeting, driven in the work, were 9 × 7 inches. The angles secured to it were 3 × 3 inches. The groove, thus left for the adjoining sheet-piles, would thus be about 1 inch in thickness. The plates used for the sheet-piles proper seem to have been ¾ inch in thickness. Their width was 25 inches. The reinforcing T-bars were, apparently, 3 × 5 inches. Upon examining the elevation shown in Fig. 14 it will be seen that additional reinforcement was deemed necessary, particularly of T-bars at the bottom. The form of the point of the sheet-pile will be noticed, especially the horns for the clearance of the grooves when driving.

What will strike the attention of the American engineer is the elaborate arrangement adopted for maintaining the alignment of this piling during the driving operations. It was necessary to provide a working platform for the pile-driving apparatus, so timber piles were driven to afford a support. Two rows of these piles, 10 feet apart, were driven, one row to the front and one to the back of the line where the piling was to be placed. Heavy walings were secured to these, leaving a free interval of 8 inches. Distance-blocks were arranged, with intervals of 15 inches between them, to permit the introduction of the main piles, 7 × 15 inches in section. These blocks were of such length as to regulate the intervals between the flanges of the main piles at 25⅛ inches. There was thus a clearance of ⅛ inch allowed for the introduction of the sheet-pile proper. The main piles were first driven, then the intervening sheet-piles. It is said that this work of driving the piles was so accurately accomplished that but one special

closing pile was needed on the whole work.[1] Very few sheet-piles jammed.

The driving was, for the most part, accomplished by the use of the ordinary method. However, in very hard ground the water-jet was brought into requisition. There were, in fact, two jets used with each pile—one to the front, the other at the back. The down-pipes were diminished in cross-section at their lower ends.

It is undeniable that the employment of so great a quantity of steel-sheeting for permanent construction in this large English undertaking means the beginning of a general adoption of steel for sheet-piles by British engineers. Perhaps it may not be amiss to point out that this style of sheeting seems to have the disadvantage of an imperfect interlock. It is possible to withdraw two adjacent piles from each other by a lateral movement. This same defect attaches to the cast-iron sheeting used in the Asyût and Zeifta barrages in Egypt. That such an interlock may become ineffective seems to be pretty well disclosed by the bulging taking place in both trial-bays. In the first, the integrity of the steel wall was entirely broken up, while in the second a beginning of separation was observable. The writer expresses himself, of course, with some diffidence; but ventures, however, to point out that, although it is quite possible that the curtain-wall at the Hodbarrow mines may now be intact and may remain so, it would seem just as well for engineers in the future to make sure by using an interlock that is effective in every direction except the vertical. This particular construction is now some five or six years old, and has, apparently, successfully been withstanding any thrusts of the surrounding strata tending to impair its continuity.

[1] In the discussion following the reading of Mr. Bidwell's paper on the Hodbarrow Mines, it was stated that but one row of walings was used. This seems to be in conflict with the text of the paper itself.

An entirely different form of steel sheeting, used in English construction going on at about the same time as that at the Hodbarrow Mines, may be noticed. This sheet-pile was decided upon because of the apparent impossibility of driving wooden sheeting for a portion of a coffer-dam employed in construction of the Tredger dry dock at Newport, Monmouth. In seeking to drive the intermediate wooden sheets between the main piles one hundred blows of a ton-and-a-quarter-ram having a fall of 6 feet were required to secure a penetration of 1 inch. Success in driving the steel forms was attained not merely because of the strength and stiffness, but because of the 87½ per cent. reduction in cross-sectional area. This type of sheet-pile consists of units formed by riveting together a channel and an I-beam. A flat plate was secured at the same time to the inner face of the channel. The channel thus formed a groove into which the free flanges of the adjacent pile would be inserted. The purpose of the flat plate was to provide a suitable contacting surface for the next pile. It was feared that the rounded corners in the channel would otherwise make a proper contact difficult. This piling was, however, not successful in effecting tight joints. Indeed, it is rather difficult to see how it could be so, no provision having been made to seal them. However, these piles seemed to drive with ease. With the same ram a fall of but 3 feet was used. It is stated that continuous driving was economical of power. If driving ceased at night, the number of blows required, on resuming in the morning, would be increased 50 per cent. to accomplish equal penetration. Perhaps attention should be directed to the defect of an imperfect interlock, shared by this pile with a number of others.

(*To be concluded.*)

VANADIUM STEEL

By William E. Gibbs, B. Sc.

IT is now eighty years ago that Berzelius, in a letter to Dulong, wrote as follows:

"M. Sefström, the Director of the Fahlun School of Mines, while examining a piece of iron remarkable for its extreme softness, observed the presence in it of a substance which differed in its properties from every other known substance, but present in such small quantity that much time and expense would be necessary before a quantity could be obtained sufficient for a thorough investigation. The iron is obtained from an ore found at Taberg in Smaland, which also contains small traces of the substance mentioned. M. Sefström, having observed that cast iron contains a much greater proportion than the wrought iron which is obtained from it, assumed that the slag formed during the conversion of the cast into the wrought iron would be still richer. This supposition has soon been confirmed by experiment, and M. Sefström, having been able in this manner to procure a quantity of the substance sufficient for investigation, has come to me for the Christmas vacation to complete his researches on the subject."

While Sefström's observations were found to be correct in the broad sense, yet subsequent detail observations have shown that a large portion of the vanadium in the ore passes into the slag of the blast furnace. Subsequently a further great elimination takes place from the pig iron when it is converted into steel in the acid hearth; if the conversion takes place in the basic hearth, then, of course, practically all the vanadium is eliminated from it.

Sefström completed his researches and established the individuality of the element and described many of its compounds. He named it vanadium in honour of the Scandinavian goddess Freya, or Vanadis.

At the beginning of the century, Del Rio, a mineralogist in Mexico, had discovered a new element in the lead ores of Zimapan in Mexico. He ascribed to it the name erythronium, from the reddish colour of its compounds when heated with acids. Del Rio appeared to be somewhat uncertain of his discovery, for in the following year he changed his mind and expressed it as his opinion that the ore was merely a basic chromate of lead.

In 1831, the year after Sefström's discovery, it was shown by Wöhler that vanadium existed in the lead ores of Zimapan.

A most thorough and complete investigation of the metal and its compounds was commenced in 1867 by Sir Henry Roscoe. The metal is very hard and has an extremely high melting-point (above that of platinum). It has a very great affinity for oxygen and nitrogen.

Although vanadium has been employed successfully in ceramics and in dyeing, yet its most important application is to the manufacture of "special" steels.

The large number of uses to which steel is put, the variety of the conditions which it must fulfil, have created a demand for special steels suited to the particular requirements of the engineer and the manufacturer. Steel which answers admirably to the purposes of bridge-building would be of little use in high-speed

tools or in the driving-rods of locomotives. During the last two decades the requirements of engineers have been increasingly exacting. Steels that satisfied the requirements of twenty years ago are quite unsuitable to-day.

A marked change is noticeable in the engineer's conception of the "useful strength" of a steel. Formerly it was the custom to gauge the quality of a steel by the maximum load it would stand before breaking and its elongation under such a load.

Other qualities observed were (1) the elastic limit, *i. e.,* the stress it would stand without sustaining permanent distortion, and (2) the contraction per cent. in the area of the cross-section when broken under a steady load. Of these four tests the two last seem to be the most valuable, and they are gradually supplanting the two former ones in the considerations of engineers. It does not seem likely that a steel would be employed under a stress greater than that required to permanently distort it, *i. e.,* the elastic limit; also the contraction in area of the cross-section appears to be a better indication of its static ductility than its elongation, or longitudinal flow. However, the knowledge of its tensile strength, its elongation, and also its behaviour when bent cold sufficed for the requirements of the engineer twenty years ago.

But however able a steel may be to withstand a steady load of considerable magnitude, it does not necessarily follow that it will behave well under stresses suddenly applied, whether large shocks or persistent vibratory forces. It is well known that it is possible to break a steel by the repeated application of forces far below its elastic limit. A steel often possesses both "static" and "dynamic" strength, but this is not always the case, and a steel with superior static qualities will sometimes quickly deteriorate in service and ultimately break down under heavy "duty." Numerous instances of such deterioration have been observed in connnection with the axles of automobiles, etc., where increased static strength has too often been accompanied by inferior dynamic properties. This is particularly the case with nickel steels. Nickel greatly enhances the static properties of steel, but dynamically it is a veritable poison.

Since steels are so prone to deteriorate no clear conception of their usefulness in service can be obtained which does not include some knowledge of their behaviour when subjected to shock or vibration. Therefore steels are now subjected to a severe dynamic test as follows: A bar of steel, of given dimensions, is clamped at one end in a vice. Over the other end is slipped a slotted arm which is capable of rapid oscillation. At each swing of the arm the bar is bent backwards or forwards and, in addition, is subjected to shock. The number of alternating blows under a given force of impact sustained before fracture ensues defines the dynamic quality of the steel. It is found that the dynamic properties of steels vary very much with the composition and with the static properties. The day is fast approaching when all engineers will include such a dynamic test in their quality figure. Mr. W. L. Turner has proposed a quality figure which embraces the three most important characteristics of steel for constructional purposes, viz.:

(1) The elastic limit, which represents the useful strength;

(2) the contraction in area of the cross-section, which is a measure of the static ductility;

(3) the dynamic figure, which shows the ability to resist fatigue. This can be defined quantitatively as

$$\frac{E \times R \times A}{1,000,000},$$

where E is the elastic limit in pounds per square inch, R is the contraction per cent. of the area of the cross-section, A is the resistance to alternating stresses *under Turner's standard conditions.*

It will thus be seen that for a steel to have a thoroughly satisfactory quality figure it must possess great static strength and must be able to withstand vibration.

These remarks apply more directly to steel that is used for constructional purposes; but in steel that is used for tools the quality of "hardness" is most important. The hardness of a steel depends upon (1) its composition, and (2) its heat treatment. Intense hardness such as is necessary for iron turning was formerly obtained by having a high percentage of carbon in the steel. But when the tool became well heated, as in high-speed turning, then it lost its hardness, and mainly because it contained so much carbon. Here the metallurgist has invoked the aid of the microscope and the pyrometer, and by their means he has been able to understand this softening and, in a measure, to prevent it.

The loss of hardness in high-speed tool steels is due to a rearrangement among the particles of the carbon in the steel. The carbon in the steel is combined with some of the iron in the form of carbide of iron, which is distributed in lumps throughout the remaining mass of carbonless iron. On heating the steel to a certain point the carbide "areas" break up and the carbide is disseminated throughout the iron in the form of a solid solution. Gradual cooling of the steel brings about the reformation of the carbide "areas." Sudden quenching, however, prevents the dissolved carbide from segregating, but produces an intensely hard, solid solution of the carbide in iron, known as martensite. The hardness of steel is the direct result of the presence of this constituent. In service such a steel used as a high-speed tool would, on becoming highly heated, undergo this internal rearrangement, involving the decomposition of the martensite and the consequent loss of hardness. It is with the object of preventing the decomposition of this hard constituent at the working temperature that special high-speed tool steels are manufactured. They are alloy steels and may contain tungsten, molybdenum, chromium and vanadium.

Apart from their effect upon the hardness of the metal, the segregated carbides are a source of weakness. The different coefficients of expansion of the carbides and the iron cause slight—microscopically small—cracks at the boundaries of the carbide crystals. These constitute little rifts, which under stress, whether static or dynamic, will slowly widen and result in ultimate disaster.

While annealing is employed to break up the carbide areas, and to distribute the carbide throughout the iron, it also serves to relieve the internal stresses produced by the work which has been put upon the metal. Another important source of weakness is the presence in the steel of dissolved gases, oxygen and nitrogen. They make the steel very brittle.

In 1900 Professor Arnold, of Sheffield, carried out a thorough investigation of the effects of vanadium upon the properties of iron and steel. The vanadium was added to the steel in the form of ferro-vanadium, an alloy of iron and vanadium, containing in this case a small percentage of aluminium. Systematic tests were carried out and the properties of the vanadium steels were closely studied. To illustrate the general effect of vanadium upon iron and steel I quote the following figures:

INFLUENCE OF VANADIUM UPON SWEDISH IRON.

Specification	Vanad., Per Cent.	Elast. Lim., Pounds	Contract. in Area, Per Cent.
Swed. bar iron..	0.00	26,800	50
Swed. vanadium.	0.85	45,120	72

Here we have a very marked improvement in the static properties of the iron. The elastic limit is equal to that of a mild steel, while the ductility, as represented by the contraction in area, is even greater.

But the effect of vanadium upon iron, although very marked, is not so great as its effect upon steel, as the following facts will indicate:

INFLUENCE OF VANADIUM ON CARBON STEEL.

Specification	Vanad., Per Cent.	Elast. Lim., Pounds	Contract. in Area, Per Cent.
1.1 carb. steel.	0.00	67,000	7.0
" "	0.14	96,120	6.9
" "	0.29	99,320	10.0
" "	0.58	144,800	7.6
" "	0.77	131,300	9.3
" "	1.11	120,600	17.6

It is evident that the addition of vanadium greatly enhances the static strength of the steel and that the effect is proportional to the amount of vanadium added up to a certain limit. About 0.6 per cent. is the maximum amount of vanadium to be added to a steel such as the above. There is nothing to be gained by adding more than this quantity. The increase of useful strength is not accompanied by any decrease in the ductility of the metal—if anything this is slightly increased.

With regard to steel castings the following comparison is very instructive:

Steel	Elastic Lim., Pounds	Elongation, Per Cent.	No. of Alternat. Shocks
Ordinary	36,300	20	4,206
Vanadium	45,620	23	12,776

The test-pieces were taken from cast-steel locomotive frames. The greatly increased dynamic figure is very noteworthy.

So much, then, for the influence of vanadium upon ordinary carbon steel. But it is upon the properties of other "alloy" steels that vanadium exerts its greatest influence, and in this field of work it produces the most remarkable results. It appears to intensify the static effect of any particular ingredient, such as nickel or chromium, while in addition to this it toughens the steel and improves its dynamic quality. A comparison of the more important properties of several alloy steels with the various vanadium alloy steels will indicate the greatly superior qualities of the steels which contain vanadium:

Steel	Elastic Lim., Pounds	Contract. of Area, Per Cent.	No. of Alternat. Shocks
Carb. axle......	41,330	61	960
Nick. axle......	49,270	58	800
Vanad. axle.....	63,570	61	2,700
" crankshaft.	110,100	58	1,850
" gear	224,000	39	800

In addition to these the following figures are interesting in that they show the effect of vanadium upon alloy steels, such as nickel and chromium steels.

INFLUENCE OF VANADIUM UPON VARIOUS ALLOY-STEELS.

Steel	Chemical Analysis *C	Mn	Cr	Ni	V
1. Nickel forging	0.21	0.45	....	3.70	....
2. Cr-V forging	0.26	0.50	1.00	....	0.16
3. Carbon spring	1.00	0.30	....	....	....
4. Cr-V spring	0.40	0.77	1.22	....	0.19
5. Cr-V-Ni	0.30	0.27	1.51	3.45	0.085
6. Ni-V	0.24	0.72	....	3.40	0.15
7. Cr-V-Ni	0.57	0.27	0.93	2.04	0.07
8. Carbon casting	0.18	0.65	....	....	....
9. Vanad. casting	0.19	0.60	....	....	0.76
10. Carbon spring	1.00	0.30	....	....	....
11. Cr-V spring	0.40	0.77	1.22	....	0.19
12. Cr-V forge	0.30	0.50	1.00	....	0.16
13. Cr-V-Ni	0.30	0.27	1.51	3.45	0.085

Steel	Static: Elast. Limit (E) Lbs. Per Sq. In.	Static: Red'n of Area (R) Per Cent.	Dynamic: No. Altern. Stresses (A)	Quality of Figure E × R × A / 1,000,000
1. Nickel forging	61,140	62.5	746	2,851
2. Cr-V forging	61,920	57.3	1,608	5,706
3. Carbon spring	63,800	15.2	1,260	1,222
4. Cr-V spring	67,520	61.7	1,406	5,858
5. Cr-V-Ni	69,140	68.5	507	2,402
6. Ni-V	79,260	64.0	798	4,048
7. Cr-V-Ni	95,150	49.8	983	4,659
8. Carbon casting	34,690	44.9	269	419
9. Vanad. casting	44,340	44.9	850	1,671
10. Carbon spring	101,000	16.1	561	912
11. Cr-V spring	183,400	50.6	634	5,883
12. Cr-V forge	141,600	56.2	717	5,705
13. Cr-V-Ni	152,300	58.9	487	4,369

* Carbon is represented by C; nickel, Ni; chromium, Cr; manganese, Mn; vanadium, V.

Samples one to nine were annealed. The remainder were oil-tempered at 900° C. and reheated to 550° C.

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The special steels containing nickel, chromium or tungsten have now been in use for some years and have been well suited to many requirements. But where they have produced increased static strength they have caused a decrease in the dynamic quality of the material. It is by the application of vanadium to such steels that success has been accomplished and a steel obtained satisfactory both statically and dynamically. Vanadium steels have now been in use for ten years and have been subjected to severe tests. They have well justified all that was predicted of them.

The automobile industry, more than any other, has compelled the steel manufacturer to institute improvements in the quality of steel. The requirements of modern automobile construction are most drastic, and steels which prove satisfactory in service in the axles or springs of motor cars can be safely reckoned upon to stand almost anything.

Two practical examples of the superior strength and wearing qualities of vanadium steels were given in 1907, in a lecture on the application of vanadium steels to the construction of automobiles, by Mr. J. Kent Smith, the pioneer in the manufacture of vanadium steels and the highest authority upon vanadium alloys. He said:

"One automobile manufacturer could not get a steel to stand certain work, and the trouble was diagnosed by the author as a question entirely of alternating impact. In March, 1904, this manufacturer was given six vanadium steel axles of a type best fitted to resist such conditions, the understanding being that they were to be put on trial cars and punished severely, so as to form a fairly quick opinion of the nature of the steel. This manufacturer was of the opinion they would break, as the tensile strength, elongation and reduction of area were practically similar to those in the steel he was unsuccessfully using. The vanadium steel chosen succeeded triumphantly, and that man has never built a car since with any other kind of axle steel. Another illustration is that of a friend who desired shafts for a launch to transmit 80 horsepower at 1,200 revolutions a minute through 17 feet 6 inches. Carefully checked designs of these shafts in vanadium steel, showing an ample factor of safety, only came out at 1⅛ inch diameter, and despite most pessimistic remarks from "practical" men these shafts behaved perfectly under the most exigent trials. The boat in which they were used won the race (I do not say because the shafts were made of vanadium steel), and the builder stated he was designing a lot more launches and had specified vanadium steel for all. The steel he had been using before had higher static ultimate strength, good ductility and was apparently first-class steel; he was using a bigger shaft and yet he had been getting breakages."

These two instances are typical of dozens.

The best steel for moving machinery parts is chrome vanadium steel, and to this steel in particular is applied the name "anti-fatigue steel." Let us consider a sample of the open-hearth chrome vanadium steel of the type used for springs.

The annealed bar can be knotted cold, showing its extreme ductility; a sharpened end on quenching in water from 900° C. is sufficiently hardened to scratch glass. It would be difficult to equal such a combination of hardness and softness in one material.

When a steel is tempered its dynamic resistance beyond the elastic limit is, of course, diminished. A piece of the best carbon spring steel, made in the crucible, was taken, one

piece of it annealed, another tempered. A piece of vanadium spring steel was taken and tempered as for a spring; and it was found that the *tempered* vanadium steel was dynamically superior to the *annealed* carbon steel. They were subjected to the alternating stress test. The free length of the test piece was 4 inches, the section ⅜ inch square, and it was given a permanent deflection of ¼ inch each side at every vibration. Let us compare the number of vibrations necessary to break the samples: (1) Carbon steel tempered, 40 vibrations; (2) carbon steel annealed, 250 vibrations; (3) vanadium steel tempered, 350-400 vibrations; (4) vanadium steel annealed, 500 vibrations. These figures speak for themselves.

This excellent dynamic character renders vanadium steels peculiarly suitable for springs. A carbon steel locomotive spring was compared with a vanadium steel locomotive spring with the following remarkable results: The carbon steel spring under a fibre stress of 90,000 ponuds per square inch broke before reaching 10,000 compressions. The vanadium steel spring under a fibre stress of 110,000 pounds per square inch withstood 23,620 compressions without losing its camber.

Not only are vanadium steels superior in their dynamic properties, but where very good static strength is required, and where the steel will be free from shocks and vibration in service, then vanadium can produce a steel which will be hard to equal. Thus a type of open-hearth vanadium steel tempered in the ordinary shop gave an elastic limit of 224,000 pounds per square inch, with a reduction of area of 39 per cent. This steel might not be suitable for some crankshafts or driving axles because of insufficient dynamic quality, but a vanadium steel of lower static strength would meet all the static requirements in such a case and would possess a higher dynamic figure.

Vanadium steels are also eminently suitable for high-speed tools. The hardness of a vanadium steel increases with the rise of temperature, hence the cutting efficiency of a vanadium steel tool has been found to be as much as seventeen times that of an ordinary high-speed tool. As a matter of history, at the Paris Exposition of 1900 a planing machine was exhibited in which the tool, made of vanadium steel, was becoming red hot on account of its high temperature and yet *without losing any of its properties.*

Vanadium steels are good to work, a vanadium-chrome steel machining almost like a carbon steel. A vanadium-chrome steel crankshaft is a little stiffer to machine than an ordinary carbon steel crankshaft, but it is certainly no more difficult to machine than the ordinary nickel steel crankshaft and nothing like as difficult as the nickel-chrome steel crankshaft.

It is suggested that the actual effect of vanadium upon steels is at least threefold:

(1) It dissolves in the carbonless portion of the iron, which it toughens and renders more impermeable to the carbide. Thus it does much to prevent the segregation of the carbide.

(2) It removes oxides and nitrides and dissolved gases, by virtue of its powerful attraction for these gases at high temperatures. The removal of these poisonous constituents is attended by an increase in the toughness of the metal.

(3) It forms complex carbides with the other carbide-forming elements which may be present, such as chromium or nickel. These complex carbides enhance considerably the static strength of the steel. They add much more strength when they contain nickel or chromium.

We have seen that vanadium is a very refractory metal. It is manifestly impossible to add it to steel directly, its fusing-point being several hundred degrees above that of steel. But an alloy of vanadium and iron in the proportion of 1 to 2 has a fusing-point below 1,400° C., *i. e.,*

much below that of steel. It is in the form of this alloy (ferro-vanadium) that the vanadium is added to the steel. The alloy is improved by the presence in it of silicon and aluminium within certain limits. The best alloy for all practical purposes is one containing 60 per cent. iron, 30 per cent. vanadium, 7 per cent. silicon and 3 per cent. aluminium. The alloy must not contain vanadium carbide, and it is probably because electrically manufactured alloy nearly always contains this carbide that it is unsatisfactory so far as the obtaining of regular results goes.

The addition of the vanadium alloy to the metal is a point of practical importance. We have seen that vanadium has a great affinity for oxygen; it forms an acidic oxide. Therefore it must not be added under oxidizing conditions, and if the steel contains much oxygen or oxides a large part of the vanadium will be lost in removing this oxygen.

With steels made on the acid-hearth the vanadium alloy is added a few minutes before tapping, care being taken that the slag is neutral and that the steel is as free from oxygen as possible. The alloy is added in lumps previously heated, and the steel is well "rabbled" and then poured.

In the basic open-hearth process the steel is poured slowly into the ladle and the ferro-vanadium is added simultaneously, care being taken to complete the addition before any slag appears.

Similarly with Bessemer and Tropenas steel, the addition is made in the ladle.

In the case of crucible steel the ferro-vanadium is added to the molten metal about twenty minutes before pouring.

Any "loss" of vanadium during the addition is due to that portion which combines with the oxygen and nitrogen and passes into the slag. It is imperative, therefore, to deoxidize as much as possible with the cheaper agent, manganese, before commencing the addition of the ferro-vanadium.

Until quite recently vanadium was regarded as a "rare" element, and the supply of the metal seemed to be very precarious. The first really big impetus to commercial vanadium was given by the opening up of large deposits of vanadium ore in South America by the American Vanadium Company. In addition to this the International Vanadium Company, Ltd., possesses deposits of raw material of at least equal importance in Western America and in Europe. These deposits are, if anything, more prolific in quantity than those of the American Vanadium Company and they are in a still more accessible country. It is obvious, therefore, that there is no chance of any shortage in the supply of commercial vanadium alloy, however much the application of vanadium to the general steel trade grows. During the last year works have been erected at Garston, near Liverpool, by the International Vanadium Company. They are for the production of ferro-vanadium, cupro-vanadium, and vanadium alloys in general. In addition to these two companies there is the General Vanadium Company of America.

The discovery of easily worked sources of vanadium, coupled with the commercial demand for the metal, has resulted in an astonishingly rapid cheapening of the price. Twenty years ago vanadium was £90 per pound. In ten years the price fell to £3 per pound. To-day its market price is 22 shillings per pound. It is this fact, together with the necessity for adding it to steel in very small quantities (generally less than 0.2 per cent. of the weight of the steel), that enables the manufacturer to make vanadium steels at a price roughly comparable with that of ordinary nickel forging steel. Taking into consideration its superior qualities it is without doubt the most useful steel on the market.

Vanadium, like aluminium, osmium and tantalum, is an instance of the

immense potentialities of undeveloped nature. It is by means of the elements of rare occurrence and seemingly of only academic interest that great steps are made along the road of progress. Vanadium has been well called the "Master Weapon of the Metallurgist," and in the hands of such master metallurgists as Professor Arnold, Mr. J. E. Stead and Mr. J. Kent Smith it has proved a veritable "Excalibur." Not yet has it been signally defeated, although it has been employed for over ten years, and during that time it has been subjected to the most drastic tests that could be devised.

Its usefulness is not confined to iron and steel, but it also strengthens and enhances the properties of brasses, bronzes, copper, aluminium and even lead. The full extent of its usefulness, however, is as yet quite unknown. There are an innumerable variety of questions concerning its applications in other branches of metallurgy which await investigation by the scientific metallurgist. We have seen what has already been accomplished, and it is such knowledge that is the best indication of what we may expect in the future from this valuable auxiliary in the improvement of steel.

CITY TRANSPORTATION

By Frank Foster, M. Sc.

MOST towns have existing transportation systems which, by reason of the capital sunk in them and the difficulties of a transitional period, cannot always be altered even to effect an obvious improvement. The writer is fully sensible of this great and frequently insuperable practical difficulty in the way of transportation improvement, but thinks that it may, nevertheless, be profitable to elucidate a few general principles which should be kept constantly in mind by those having to deal with city transportation.

A large town is to-day impossible without extended transport facilities, and it is perfectly certain that the growth of the town is in no small degree influenced by the efficiency of the local transportation systems. Especially is this true of business as distinct from purely manufacturing towns, although it is also true of the latter. The tendency for business firms is to concentrate into the large towns and into one small central district of the large towns. The economic advantages of such a gathering and concentration of business interests are considerable. But in economics distance is measured by time, and not by miles. Two towns which are equally accessible from a third are, from an economic point of view, equally distant from it, though in point of fact one may be ten miles and the other thirty.

The statement that economic distances are measured by time requires some amplification, and, perhaps, modification. As regards the "time" distance between two towns, frequency of service must be taken into account. In the case of towns, or other stopping places, which are close together, frequency of service is of the greatest moment, and may often reverse the apparent distances as calculated from a consideration of the running times alone. For instance, if A is distant 10 and 15 minutes on the car from B and C, respectively, it would seem at first sight that, economically, B must be nearer A than C. Suppose, however, that there is a twenty-minutes' service to B and a four-minutes' service to C. Then, clearly, the average gross time it takes a person to go from A to B is twenty minutes (running time plus half the interval between cars), and from A to B is only seventeen minutes, so that, economically, C is nearer than B to A. There is a modifying factor, however, which should be noticed. When the service is fairly frequent people do not trouble about a time table, but merely wait until the first car comes along. In this case the average gross time, as calculated above, is a true measure of the economic distance. On the other hand, when the frequency is low, travelers make use of time tables and fill in time which would otherwise be spent in waiting by some useful occupation. Hence, the longer the time interval between cars or trains the more nearly does the actual running time approach to the economic time. In such cases the particular times at which cars arrive and depart becomes of importance and affects the economic distance.

The modifying influence to which reference has been made is that of cost. It is not possible to express this

in mathematical form, and hence its estimation demands the more thoughtful and skilled consideration, for in practice the influence of cost has to be taken into account. Either it must be estimated in the most careful and skillful manner possible, or it must be settled by sheer guesswork; and it hardly needs emphasizing which is the better method, although it is quite certain that the guesswork method is the favourite with a great many transportation managers.

Perhaps there is no town in the world which exhibits with greater certainty the influence of local transport upon a city's growth than New York. Every successive improvement in transportation has proved but a temporary relief to the congestion of the cars, showing emphatically that the economic growth of the city was being held in check by the inability of the transportation systems to weld into one industrial community as many people as business considerations made desirable. First, the street cars were reinforced by the overhead street railway. Then electrification effected a temporary relief, but the construction of the four-track subway soon became a necessity. Similarly, the traffic between New York and Brooklyn outgrew the by no means small capacity of the famous Brooklyn Bridge, and it was necessary to build successively within recent years the Williamsburg Bridge, the Blackwell's Island Bridge (opened this year), and the Manhattan Bridge, which is not yet finished. In addition, there has recently been completed one tunnel, and another is in progress; added to which mention must be made of the ferries.

Whilst the most perfect local transportation will not create a large population if other essential business conditions are absent, it is yet necessary to emphasize how greatly a growing community is dependent upon its transport; and it is the business of the transportation manager to give the city the best service possible, with a view to extending the business or manufactures of the district and, incidentally, adding to the traffic receipts and profits.

In order to create traffic the most important objective is to reduce the economic distances; and, as we have seen, the three most important elements in this are speed of traveling, frequency of service, and cost. In view of the experience of the London underground services, it is wise, perhaps, to also mention comfort as a traffic creator, although London in the mass has been so long without decently comfortable trains or 'buses that the people have come to look upon discomfort as a necessary part of a local journey.

It would be a good thing if our tramway managers paid more attention to the economic geography of their districts, as there is a marked lack of discrimination and initiative in tramway policy. Let us consider a typical business town, simplified to permit simple and plain statements, but still in its essentials representative of actual conditions.

In the centre of the town there is an area devoted mainly to business, and this is surrounded by a deep fringe of residential district, which, again, has on the outside—sometimes connected, sometimes separated by half a mile or a mile of fields—a number of suburban districts. All these want connecting up by a transportation system. The most important demand is for a reduction of the economic distance between the business quarter or centre and the outer districts. This involves a cheap service, a frequent service, and a fast service. This last is not appreciated either by officials or passengers. There is still in most people's minds a deep-rooted idea that a tram, because it runs in the streets, must not greatly exceed the other traffic in point of speed. And, too, passengers have a belief that they have an undoubted right to stop a car wherever they please. The greatest of tramway reforms—and it is bound to come—will involve the abolition of

these two ideas. Much higher average speeds than are at present in use *must* be attained; and these involve higher running speeds, more rapid acceleration, fewer stops, and shorter stops. Also, tramway engineers will do well to pay more attention to the tram routes, so as to avoid curves (and particularly corners), points, and crossings.

In order to reduce the number of stops, express cars are required, which will stop, as at present, near both ends of the journey, but not at intermediate points. This involves passing loops for the local cars to stand on, or a special express track. The latter is preferable, if there is sufficient traffic. In some cases in America the express track is a single line, and cars only run in one direction upon it at any given period of the day, the direction depending upon the direction of the natural flow of traffic—to town in the morning and from town in the evening. Express cars, it may be mentioned, in spite of their higher average speeds, take much less current than stopping cars.

For commercial and social reasons traffic managers should strive to reduce the residential belt which presses closely round the business quarter. The congestion in this district is the cause of slums. The slum is a social evil, and even from the tramway point of view it is an evil because its inhabitants have neither need nor the means to ride. Also, by making the residential quarter more compact, it discourages riding among the working classes who can afford to ride. Hence it is desirable to reduce the first residential belt. To do this it is essential that the economic distance between the suburbs and the town should be reduced. Speeds must be greatly increased and fares reduced. Both are possible with express cars, but the tramway manager must be prepared, if necessary, to sacrifice his short-distance passenger. The passenger who lives within the first residential belt must be distinctly discouraged in his attempts to reach town and encouraged in his attempts to fly from it.

This cannot be accomplished by appeals to health considerations. The only effective instrument is economic. For instance, suppose that in our large town the fare is put at three halfpence to the outskirts and twopence to the outlying suburbs. There will certainly be a demand for a penny fare to the first residential belt, or, perhaps, even for a halfpenny fare. This should not be granted. The least fare to any residential district should be that to the outskirts, so that there is no economic pressure tending to encourage residence in the inner residential belt. Generally, it will be possible to carry passengers to the outskirts for a penny fare; but if not, the penny fare should be abolished and, of course, the halfpenny fare, too.

This statement needs verbal modification, although not in principle. Penny, and even halfpenny fares, may legitimately be adopted on routes such as are referred to above, provided they do not connect home and the business quarter. But a series of cheap fares within the business quarter itself and another similar series in the residential quarter, but the two systems not connecting with each other, are most desirable. To fix our ideas, suppose that the run of the car from town is made up as follows: Three-quarters of a mile of business section, one mile of dense residential belt, one mile of outskirts, and one mile of country suburb. The fares are fixed at twopence to the suburb and three half-pence to any point nearer town. The cars will be only partly filled at both ends of the journey. Hence, it will pay to institute a series of halfpenny or penny fares covering the three-quarters of a mile of business section and the outer two miles of the outskirts and suburb. Such fares would prove a real boon to business people at the one end and to residents at the other. At the same time, they would not in

any way encourage thrifty or poor people to herd close in to the town. The influence of time is potent enough in this direction without adding economic pressure to intensify the evil.

With regard to the position of suburban tram routes, these should not be too close together. They should be kept so far apart that there is a tendency—a visible tendency—for vacant land and fields to be left between the tram routes, as this preserves the social and sanitary standard of the district and encourages the town to grow in the form of a starfish, rather than to cover up the whole ground, which is a thing to be prevented. Although the main tram routes will connect the outskirts to the centre, there is usually a profitable opening for cross-town or intersuburban routes.

Turning now to the business quarter of the town, we generally find an altogether inadequate appreciation of the value and possibilities of transportation facilities. We have already pointed out that a series of cheap fares within the business area would prove a real boon, but they are never adopted. Further, tramway managers have become possessed with the false idea that all services should start from some one common place, so as to interconnect.

This idea is probably borrowed from the railways, but it is a mistaken one. The number of passengers who desire to make train connections is only a very small proportion of the total, and hence their needs are only of secondary importance. Further, most of them are unencumbered, and can easily walk some little distance, if necessary, although it should be avoided if possible. But the tram which starts from a common central square or depot necessarily only traverses half the business section, and is, therefore, a defective carrier. In the first place, it does not link up the opposite parts of the business quarter, and, in the second place, it does not carry its passengers as near, on the average, to their destinations as it might.

In fact, it may be taken as a general principle that a car should start from near the far side of the business quarter and traverse the full width. It should, if possible, pass through a central square, in common with all other cars; but it should not start from that square.

It has frequently been proposed that cheap contract tickets, available for more or less prolonged periods, should be issued on tramways between certain definite points. In the sense in which these are intended—as an imitation of the railway contract-ticket—they are quite unjustifiable on any ground. In the majority of cases the contract would not create traffic; it would only cheapen traveling. Now, in the majority of cases tramways cannot afford to cheapen traveling unless they at the same time increase the traffic. We have already indicated the way to increase the traffic—by discouraging the inner residential belt. Contracts are intended to encourage the regular traveler. On the railways this is possible because, as a rule, the passenger has the option of living close in and refraining from using the railways or of moving out, in which case he must use them. Hence, the railway must either give him sufficient inducement to live out or lose him altogether. On the tramway the case is different. In the majority of cases the man has no option, practically speaking. He must ride, and it is merely a question of distance. It is, as we have seen, a paying policy to discourage the inner residential belt and encourage a reasonable suburban tendency; but it is not possible to carry this very far, for as long as there is an appreciable amount of unoccupied land near the centre of the town the people will refuse to go further out. Hence, there is no sense in carrying a man who goes regularly at a less rate than the occasional passenger. It does not increase the traffic. Consequently, the

working expenses are not reduced.

Indeed, so far from encouraging the regular traveler, the tramway management should endeavor to encourage the occasional traveler, because he or she, in all probability, will travel in between the rush hours when the cars are more or less empty and not earning their expenses. In fact, if the system could be practically arranged cheap fares should be adopted for the non-rush hours. The tramway of a city system and the railway connecting the more remote districts are economically distinct. The one has a fairly fixed regular traffic, which taxes its resources at certain periods only and leaves certain blanks badly in need of filling up, whilst the latter system has to make its regular traffic by offering inducements. It is true the railway desires to fill in its non-rush blanks as fully as possible, but the railway is there primarily to attract the contract-ticket holder. The railway performs a service for a private individual, but the tramway approximates to performing a public service rendered necessary by the economic or business needs of the community as a whole. Hence, the tramway must charge alike to all of the public who seek to use it at any time. There must be no distinction between individuals. Any distinction must depend only on time or local geography.

Current Topics

THE administration of government is becoming more and more a scientific operation. The welfare of the citizens depends upon the maintenance of order, the preservation of peace, and the opportunity of pursuing the occupations upon which comfort and prosperity depend. The responsibility of the ruler thus becomes increasingly important, and in no case has this burden of responsibility been more fully accepted and thoroughly borne than in the case of the King who has just gone to his rest. The title of Edward the "Peacemaker" far outweighs all the appendages of "conqueror," "victorious," "bold," or even "great," which have, by common consent, been bestowed upon monarchs of other times; it means an acceptance of the truth that the "true grandeur of nations" lies, not in military supremacy, but in the wise control of conditions rendering destructive warfare unnecessary, and assuring well-earned supremacy by the maintenance of peace.

The great poet of the English-speaking race has voiced the responsibility of the monarch in the words of Henry the Fifth, who, in realizing the burden of his high office, is made to speak the memorable words:

"Upon the King! Let us our lives, our souls,
Our debts, our careful wives,
Our children and our sins, lay on the King;
We must bear all.
O hard condition! twin-born with greatness,
Subject to the breath of every fool, whose sense
No more can feel, but his own wringing!
What infinite heart's-ease must kings neglect,
That private men enjoy?"

WITH the increasing cost of all kinds of industrial operations it is becoming evident that the success of most manufacturing establishments must depend upon the development of maximum efficiency, which means that all wastes must be reduced and all unnecessary expenditures eliminated. It is not difficult to cut out losses when their causes are well known, and thus the principal effort must be directed toward the detection of the leaks and the places at which they can be stopped.

When the skilful physician is called in to treat a case of which he has had no previous knowledge his first effort is to make a diagnosis and endeavour to discover symptoms which shall guide him in determining the causes of which they are the effects. In like manner the engineer who is attempting to convert losses into profits, and to reduce wastes, both with men and machines, must find out where the things which cost money are escaping without rendering due return; he, too, must make his diagnosis, and be guided by symptoms in the effort to discover just where the unprofitable outlets are situated.

The symptoms of losses in engineering problems may be discovered largely by a proper realization of the law of conservation of energy. Every manifestation of any one of the physical forces, so-called, means an expenditure of energy. Some of these manifestations are desired and capable of utilization; others are, at present, not utilized, and the energy to which they owe their existence is therefore wasted. Among these symptoms of unused energy, in many instances, we may include heat, noise, vibration, and, in general, unnecessary movements.

It is well known that rejected heat, that is, heat which has been generated at much cost of effort and money, and which is discharged unused, is a distinct evidence of waste; it is so well known that nearly every one looks upon it as an indication of the place to make a saving. To this realization we owe nearly all the efforts to introduce condensers, superheaters, exhaust-heating devices, and similar appliances. Such efforts have been among the most effective in the increase in efficiency of prime movers, and their continued application will doubtless reduce the losses in heat motors still further.

Of the other indications of waste, however, we can say hardly so much. There is probably no clearer symptom of wasted energy than the production of noise. The surest indication of this fact appears when it is desired to produce a loud and penetrating sound, such as is demanded for signals of warning along the coast, including the various forms of so-called sirens and similar appliances. To make a sound of this sort requires far more power than would be ordinarily supposed, while for a similar purpose, the sounding of a steam fog-horn, the quantity of steam demanded is much greater than is generally assumed. When, therefore, any mechanical operation is accompanied by much noise, it may be accepted as a definite symptom that there is an accompanying waste of power, and that if the noise can be prevented, not smothered, as in a muffler, there will be a notable gain in efficiency.

In like manner the production of injurious vibrations indicates the expenditure of wasted energy, while the generation of heat, as in warm bearings, heating of electrical machinery, etc., is a sure demonstration of the conversion of a portion of the effort for which the owner is paying money into a product from which he can realize only injury.

Sometimes the symptom of loss is a visual one, and while the object seen may not in itself be the direct result of wasted energy, it is a guide to its location and probable extent. Thus, the volumes of smoke emitted from the factory chimney, or the white clouds of exhaust steam floating away in the sky, show clearly the

path which useless energy is taking in wending away from the owner's pocket, and point out with equal clearness the direction to which curative effort should be directed. The smoky, noisy automobile proclaims in unmistakable language where the wasted value in the fuel is going; while the pounding of the flat car-wheel tells in loud terms of the extent to which power, which should be used in propulsion, is engaged in working injury to track and vehicle alike.

The writer was once told by a veteran engineer of the importance of "looking with the ears" when in search of a defective piece of mechanism; of listening for sounds which coincided with ocular observation as to rhythm of movement, to discover the warm bearing and the noisy loose pulley, and there is much truth in the homely observation.

No demonstration of any one of the forces of Nature, of heat, sound, light, or electricty, can be produced without a corresponding consumption of mechanical energy, and when any of these manifestations, undesired and unused, is produced, somebody is paying for it, probably in far larger measure than he suspects.

IF a steam boiler is fed with acid water it is rare to find within it any scale. Such water requires neutralizing or it will neutralize itself at the expense of the boiler. The amount of soda requisite for neutralizing the acid is easily ascertained by adding soda in carefully weighed quantities to a definite weight of water until the test with phenolphthalein shows that alkalinity has been produced, the test liquid producing a pink coloration, the fainter the better, since a deep colour shows excess of alkali. But why use expensive soda? Lime is also an alkali which will destroy acid in water. If the acid be sulphuric it will convert the lime into sulphate of lime, and it will also convert limestone or chalk into lime sulphate. Hydrochloric acid will attack the lime of lime carbonate and set free the carbonic acid or it will convert quicklime into chloride and render the water neutral.

If soda is employed and the amount is found as above, sufficient may be mixed in a tank for each day's use and set to dribble into the feed tank so as to supply approximately the necessary quantity, and the water in the boiler should be tested regularly to prove whether it be alkaline. It should always turn pink litmus paper blue.

By means of limestone chippings for filling, an acid water may be passed through a large filter tank so as to become neutralized by the large area of chips exposed to its action. Acid boils at a high temperature, and therefore becomes concentrated in a boiler and is a most dangerous impurity which should be carefully guarded against. By the use of lime, scale can in time be caused to form on the plates. If it becomes too thick, it can be thinned away by omitting further additions for a time. The acid will very soon get rid of it. If scale forms and the water is acid, this is a proof that the water contains sulphuric acid and sulphate of lime. For such a case lime addition is less valuable and soda must be employed. The reaction of soda with sulphate scale is to convert the lime sulphate into sulphate of soda, which, being very soluble, remains in solution, and, of course, becomes concentrated and will, if not blown out, fill a boiler with crystals of glauber salts.

It is often noticed that beneath a heavy scale of sulphate of lime the plates of a boiler show considerable corrosion, which is attributed either to decomposition of the scale, in the presence of the iron plate, or to the presence of free acid in water containing lime sulphate. The remedy again is soda. Enough of the soda should be carbonated to deal with the lime sulphate, and the rest may be the same so far as cost goes. Otherwise, if cheaper, caustic soda would deal with the acid, or anhy-

drous soda ash may be employed. Soda crystals are needlessly expensive, and no advantage is gained by their use as against dry soda ash. The problem of water treatment is much more serious now that pressures are so much higher. Waters that were well enough in the days of less pressure may contain salts that decompose at high pressures, and may give rise to acids of a most destructive nature.

THE law of demand and supply, to reverse the usual order, is found in operation in engineering development as well as in commercial operations, and indeed the two lines of effort are so closely connected in modern times that it is difficult to mark any distinct line of separation. In our last issue the situation of the rubber trade was set forth by Mr. Heinsohn in a manner entirely free from any speculative elements, the question being discussed solely upon the relations of the two controlling elements of production and consumption. The latter has overtaken the former, the demand is pushing the supply, and the markets are correspondingly affected.

In the present number of this magazine the series of articles upon the railways of Brazil reaches the examination of the Madeira & Mamoré Railway, a piece of engineering work constructed almost wholly in order to enable territory containing vast supplies of crude rubber to be reached at a cost which will be commercially practicable.

It is the development of certain departments of engineering work which has caused the demand for rubber to exceed the present supply; the automobile, the use of rubber belting for transmitting power and conveying materials, of hose for conveying liquids, of sheet rubber for multifarious uses—all these applications of the once worthless gum have made it an essential article of commerce. When the demands of the engineering industries have overtaken the supply the engineer himself proceeds to meet the emergency, and thus it is that modern machinery, trained engineers, and modern sanitation are joined to push two hundred miles of railway through the Brazilian forest that the rapids of the Madeira river may be "short-circuited," so to speak, that transport between the sea and the interior of Brazil and of Bolivia may be placed upon a modern basis, and that the supply, not only of crude rubber, but of all the vast natural resources of a wide and rich country may be placed at the service of a civilized world.

A. FREDERICK COLLINS

A BIOGRAPHICAL SKETCH

EVER since it became a demonstrated fact that telegraphic messages could be sent through space by the aid of magnetic waves it has been felt that some similar method of communication by telephone through the air might become practicable.

The subject of our sketch has devoted a large portion of his career in the study of this problem, and the results have been successful to such an extent that wireless telephony has been placed upon a commercial basis and is meeting with various useful applications.

A. Frederick Collins was born at South Bend, Indiana, in 1869, being the son of Captain Thomas J. Collins of that place, and received his education in the public schools and at the old university of Chicago. In 1888 he commenced practical electrical work with the branch of the Thomson-Houston Electric Company in Chicago, and thus acquired experience with electrical appliances and the study of electric currents. In 1898 he began investigations into radio-telegraphy, a subject which was then attracting much attention, and constructed one of the first wireless telegraph sets made in the United States. In the following year (1899) he organized the American Wireless Telegraph & Telephone Company, the first wireless company to be formed in America, and in 1900 he invented a wireless telephone, first applying the arc lamp for the purpose in that year.

In connection with his activity in the practical development of wireless telephony, Mr. Collins has become well known as the historian of the art. In 1901 he began writing for the technical press upon the subject in which he was at the same time conducting practical investigations, and nearly nine-tenths of all that has been published upon the art of telephoning through space has come from his pen, including articles in the Electrica World, Scientific American, Electricity, Electrical Review, Western Electrician, Technical World, Review of Reviews, and various foreign periodicals. He has contributed monographs upon wireless telephony in the Encyclopædia Americana, the International Encyclopædia, the Cyclopædia of Applied Electricity, the Encyclopædia of Engineering, the New Standard Encyclopædia, Nelson's Encyclopædia (London), and Experimental Science; and he is quoted as an authority on the subject of radio-telephony in these works of reference. During the period 1903-1906 Mr. Collins was scientific correspondent for the New York *Herald*. He is also the author of the following books: Wireless Telegraphy: Its History, Theory, and Practice (1905); Manual of Wireless Telegraphy (1906); Design and Construction of Induction Coils (1907); and High Frequency and High Potential Currents, this latter work being in course of preparation.

In 1903 Mr. Collins gave the first public demonstration of the possibilities of wireless telephony on the ferryboats *Ridgewood* and *McCullough* in the North River.. In 1903 he organized the Collins Wireless Telephony Company, and in the following year he began to make, advertise, and sell apparatus for wireless telephony. In 1908 he succeeded

in communicating by wireless telephone from his laboratory in Newark, New Jersey, to the Singer Building in New York City, and in the same year he telephoned from the same laboratory in Newark to the Land Title Building in Philadelphia, a distance of about eighty miles. He also invented in that year his oscillation revolving arc lamp for the production of sustained oscillations, and in the following year (1909) he was awarded a gold medal at the Alaska-Yukon-Pacific Exposition for his work upon the wireless telephone.

Mr. Collins has been indefatigable in developing the business side of wireless telephony, and in 1910 he effected a merger of the Collins Wireless Telephone Company, the Clark Wireless Telegraph Company, and the Pacific Wireless Telegraph Company into the Continental Wireless Telephone & Telegraph Company, thus forming one of the largest operating wireless companies in the world, of which new company he is the technical director and consulting engineer.

In 1908 he founded the *Collins Wireless Bulletin,* of which he is the editor and owner, a publication devoted wholly to the subjects of wireless telegraphy and telephony, and which contains much material of interest in its especial field. He is the honorary president of the Collins Wireless Society, and is a member of the Royal Society of Arts (London).

The relative importance of wireless telephony in the field of electric communication still remains to be determined, but there are doubtless certain departments in which it is destined to be very useful. For naval purposes, involving the exchange of communication between vessels forming a fleet, the telephone is adapted, and for many purposes to which the more powerful radio-telegraph apparatus is unsuited the telephone may be applied. Probably the two systems will be used in conjunction at times, and the selection made according to requirements, but it is largely due to the efforts of Mr. Collins that the wireless telephone has reached the practical stage, and that it has been placed upon a commercial as well as a scientific basis.

SAMUEL PIERPONT LANGLEY,

THE PIONEER IN MODERN AVIATION

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CASSIER'S MAGAZINE

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THE RAILWAYS OF BRAZIL

By Lionel Wiener

In the first of the present series of articles there was set forth the general conditions under which the railway systems of Brazil had their origin and early development, together with some of the modifications governing the more recent undertakings. The second paper dealt with the northern railway and river system, including the Madeira & Mamore Railway, which appears destined to open up new and vast fields of natural resources in connection with the navigation of the Amazon and its tributaries. Subsequent articles will describe other systems, the whole series covering the principal railway development of the entire country.—THE EDITOR.

III. THE GREAT WESTERN RAILWAY OF BRAZIL.

ALL the railways, or very nearly all of the lines in the northeastern States of Brazil are in the hands of an English company, the Great Western. Since the country is broken up, both in political and a geographical sense, it is an exceptionally fortunate thing that all these railways should be in the same hands. They cover the States of Northern Rio Grande, Parahyba, Pernambuco, Alagoas and Sergipe. The main line runs in a north and south direction, connecting the ports of Natal, in the north, with Parahyba, Pernambuco (called Recife in Brazil), Maceio and Parahyba, with a further extension under construction to Bahia. From each of these harbors a line runs inland, following a westerly direction, at right angles to the coast.

The Great Western Railway owns but a short line, extending from Recife to Limoeiro and Timbauba; the rest of the system is only leased and is of very unequal value. These lines have been bought up by the government at various times from the companies by whom they were built and merged into the system, and this is the probable fate in store for the Recife, Limoeiro and Timbauba Railway as well. The Central Railway of Rio Grande del Norte is still under construction and has therefore not yet been handed over.

One of the lines, the Paulo Alphonse Railway, is quite separate from the rest. It connects Jatoba and Piranhas, two ports on the Sao Francisco river, between which there are a series of falls and rapids, and thus establishes communication between the lower Sao Francisco and the enormous upper watershed that stretches away southward to the very verge of Sao Paulo.

The Great Western System, as it now exists, comprises three divisions, the northern, central and southern divisions, each made up of a number

RAILWAY MATERIAL AT THE PORT OF PARA

of formerly independent concerns, as follows:

	Miles
Northern Division:	
The Natal and Independencia Railway..........	120
The Conde d'Eu Railway......................	104
The Recife, Limoeiro and Timbauba Railway....	164
Central Division:	
The Central of Pernambuco Railway...........	143
Southern Division:	
The Recife and San Francisco Railway.........	78
The South of Pernambuco Railway.............	121
The Central of Alagoas Railway...............	94
The Ribeirao and Cortes Branch...............	18
Besides the Paulo Alphonso Railway...........	72
Total....................................	914

These lines are now all on the metre gauge; even the Recife and Sao Francisco Railway, one of the oldest in Brazil and originally built with a gauge of five feet, three inches, having been recently converted. The name Recife and Sao Francisco is an incorrect appelation, this line having been stopped short at a point many hundreds of miles away from that river. It is customary in Brazil to give names to all lines and branches, and nine times out of ten the name is incorrect, sometimes being that of a defunct company, often of towns which the promoters hoped to reach. The very towns themselves keep on changing their names, not the least among the puzzles which the railway administration has taken no trouble to solve. Thus Recife is Pernambuco, Palmares is Uno, Vicosa is Assemblea, Sao Salvador is Bahia and Sao Pedro is Rio Grande. In the railway time tables and guides the towns are called only by the name of the station; thus, Rio is not to be found, whereas Central appears. Most towns also have a saint's name besides their own, such as Sao Antonio of this, or Sao Joao of that, and are called by either name, just as if one were a family name and the other a mere intimate one. The habit of changing the names of towns is growing. When the republic was proclaimed, old names were erased and replaced by new ones, such as Federation, Constitution, etc. There were too great a number of these and hence they are gradually disappearing and being replaced by the names of local

WATER TANKS AT PARA

celebrities. We may assume that the republican feeling remains unchanged and that the alteration in names is mainly due to the desire of avoiding monotony or confusion.

Returning to the Great Western Railway, this company is a British one, floated with the object of building, leasing and operating railways in Brazil. The parent line, the Recife and Sao Francisco, is the best of these. It was built by a company and opened in sections between 1858 and 1862, starting from Pernambuco to Uno (Palmares) and passing through Ribeirao, from whence a couple of branches have since been built. It is one of the oldest lines

in Brazil, contemporary with the begining of the Pedro II. Railway, and two years older than the Bahia and Sao Francisco line. It is an easy line, with few curves and not many artificial works, the principal ones being a short tunnel and a 390-foot bridge over the Ipajuca, with 90-foot spans.

Its traffic has always been heavy, consisting mainly of sugar, of which 51,000 tons were shipped in 1908, together with about the same quantity of sugar cane and 6,200 tons of *aguardiente*, the spirits made out of it. All the coal used in the locomotives is sent out from England, no wood being used as fuel, owing to the convenience of the harbor of Recife on the line. It would seem at first sight that this is essentially a transit line, but such is not the case, the average distance, especially for passenger travel, being short. In 1907 the average was as follows:

	Miles.
First-class passengers	29.
Second-class passengers	18.8
Average passenger	20.9
Animals	38.
Luggage and parcels	39.
Merchandise	43.5

The exports are much greater than imports, the ratio being about six to one.

The rolling stock is made up of 22 locomotives, 39 passenger coaches and 540 wagons, the highest number per mile (7.06) in Brazil, with the exception of the Sao Paulo Railway.

As soon as this line had given evidence of becoming a paying concern, others were thought of. The Paulo Alfonso Railway was opened in 1881 and 1883; it supplies the missing link in the navigability of the Sao Francisco river, but very poorly, being operated at a cost of 357.67 per cent. of the gross earnings in 1907. The tonnage carried by this line is only about 2,500 tons, equally divided each way.

HAULING PILES IN THE BRAZILIAN FOREST

The South of Pernambuco Railway is the continuation of the Recife and Sao Francisco Railway and was constructed a little at a time between the years 1882 and 1887 as far as Garahuns. This line is ninety-one miles in length and is a steady uphill pull all the way, rising from 390 feet to 2,860 feet above sea level. In the meantime work had been started in Jaguara in 1884, just beyond Maceio, the capital of Ser-

BRITISH STEAMER UNLOADING COAL AT PORTO VELHO

gipe, up the Cambeto valley, and the Central of Alagoas Railway thrown open as far as Uniao, fifty-five miles to the North, near the frontier of the State of Pernambuco. There thus remained only a small piece of line to unite the two systems, joining Uniao, in Sergipe, the South of Pernambuco line. It was only in 1894, after the unification of the system that this short thirty-mile connection was built. Garahuns and the section from thence to Glycerio Junction, formerly the trunk line, has thus become but a branch of the through rail conection between Recife and Jaguara.

The Vicosa branch of the Alagoas Railway was opened in 1891 from Lourenco de Albuquerque to Atalaya and Vicosa (or Assemblea). This line runs around the Alagoas Lagunas and up the Parahyba valley, a distance of about thirty-nine miles. A bill was passed in 1909 authorizing the construction of an extension further inland to Palmeiras dos Indios, another forty miles. This line will gain considerable importance, as it runs through Atalaya, the future junction with the important Rio connection, over the rails of the Timbo and Propria line. The Central Alagoas Railway is a good road, in fact as good as the original lines of the system.

The Ribeirao and Cortez branch was originally undertaken by the State of Pernambuco. In compliance with a clause of the 1904 contract with the Great Western Railway, that company purchased the line from its former owners, undertaking at the same time to bring it into a decent state of efficiency, which was sorely needed. It had been conceded in 1881 and allowed to fall into bad repair. This district is especially adapted to the growing of sugar cane, in fact several railway lines live almost entirely upon the carriage of sugar cane.

This branch is eighteen miles long, with a projected branch extending twenty-one miles to Bonito. Another branch runs eastward from Riberiao to Barreiros, but this is an independent concern, the line being thirty-six miles long and laid upon a different gauge, two feet six inches. It is built under a Stadoal Bill.

These southern companies carried

CONCRETE MIXING PLANT AT PARA

the following quantities of sugar and sugar cane in 1907:

	Sugar, Tons.	Sugar Cane, Tons.	Aguardiente, Tons.
Recife and Sao Francisco	51,141	57,346	3,192
South of Pernambuco...	9,293	32,575	,023
Central de Alagoas......	16,136	34,015	,594
Ribeirao and Cortez.....	4,661	26,895	701

The ratio of expense to gross earnings during 1907 were 48.8 per cent. for the Recife and Sao Francisco Railway and 69 per cent. for the Alagoas Central. The two others do scarcely better than cover working expenses, the figures being 99.5 per cent. for the Pernambuco Southern and 93.8 per cent. for the Ribeirao branch.

THE CENTRAL GROUP.

The Central Group consists of a single line, the Central of Pernambuco Railway, built and worked by the Government, and only recently handed over to the Great Western Railway Company. It is a most productive line, despite the heavy expenditure it entailed, due to the difficult nature of the country through which it runs. A short portion between Recife and Tapera was opened in 1885 and it reached Russinha three years later. The Government has extended it by fits and starts, doing nothing for a few years and then throwing open a further section. Olyntho was tapped in 1896, and ten years later work was resumed to Pesquiera, the present terminal, 343 miles from Recife.

Partly owing to the excellent traffic returns and partly to a general idea of linking the Great Western System with the other northern lines, the Government intends carrying the line on toward the southern extremities of the Sobral and Baturité railways, keeping in the State of Pernambuco all the way near its northern frontier and up the Ipajuca valley. The difficult portion will begin toward the source of the river, at the limit of the watershed, just beyond Triumpho.

A TRAIL THROUGH THE BRAZILIAN FOREST

The bill of 1909 sanctioned the construction of a long piece of this extension, from Pesqueira to Flores, at the foot of the Baixa Verde Serre, which will double the line's present extension.

There are fourteen tunnels and thirteen large bridges on the first portion alone, and the remainder is certainly no easier; the first extension of twenty-seven miles is well in hand.

Recently, as the Pernambuco Railway had been handed over to it, the Great Western Railway has been laying short connection between its lines around Recife. The Pernambuco Central Railway is connected with the Union line of the southern group and with the Timbauba line of the northern group by a six-mile and a five-mile branch, both important pieces of work, as one includes a three-span bridge 495 feet long over the Capibaribe, while the other bridges over the Tigipio and the Unchoa. The cost of the northern connection was £17,817.

Two-thirds of the returns of the line, roughly speaking, are due to goods-traffic. There is less sugar than on the southern group and more cotton. Among other export articles coal should be mentioned; the only coal in the country other than in the extreme South. In 1907 the line exported the following quantities of these articles:

	Tons
Sugar	5,243
Sugar cane	9,605
Aguardiente	1,295
Cotton	5,028
Coal	9,703

Importation is about one-third of the exportation. The company owns twenty-four locomotives, forty-two coaches and 188 wagons.

THE NORTHERN GROUP.

This was the birthplace of the Great Western Railway Company. The Recife, Limoeiro and Timbauba Railway is its own property, held under a government concession. The Recife and Limoeiro line is 164 miles long and the Carpina branch to Timbauba, on the frontier of the State, in thirty-six miles in length. The line was opened to Pau d'Alho in 1881 and to Limoeiro in the following year. The northern portion was then but a small branch to Nazareth, just a little further. A special feature of the system is that the original trunk lines have nearly always become branches, owing to the fact that connections have been built some distance nearer the coast.

The Nazareth branch was pushed on to Timbauba in 1888, and a further portion, across the frontier to Pilar, was opened in 1901, adding sixty-one miles and opening communication with the Conde d'Eu Railway in the neighboring State of Parahyba. This last portion, together with the branch from Itabaianna to Campina Grande, a distance of fifty miles, still remains Government property and is only worked by the Great Western Railway.

The Conde d'Eu Railway, which continues this line, bears the name of the son-in-law of the Emperor Dom Pedro, whose name, like that of his daughter Leopoldina and his wife Thereza Christina, has been preserved by the railway companies, while his own has been erased: a revolution is no reason to cause these names to be withdrawn as criminal, a fact which the British-working companies have understood.

This Conde d'Eu line keeps to the banks of the northern Parahyba River, from Parahyba, the capital, situated a short distance up the estuary up to Cobe, near the junction with the Recife line. It then curves northward to Independencia, with a short branch to Alagoa Grande.

The original line between Parahyba and Independencia was built in 1883. It has been extended downstream to the sea shore, at Cabedello, in 1889 and up the Maranguape River to Alagoas in 1891.

From the quay at Cabedello there is a continual slow rise to Cobé half way, where the hard pull begins. The next station, Sapé, is but eight miles distant and is 285 feet above Araca, 70 feet higher is on the top of the plateau which the line follows to the terminal. It crosses the Parahyba upon a bridge 792 feet in length, with spans of sixty-six feet.

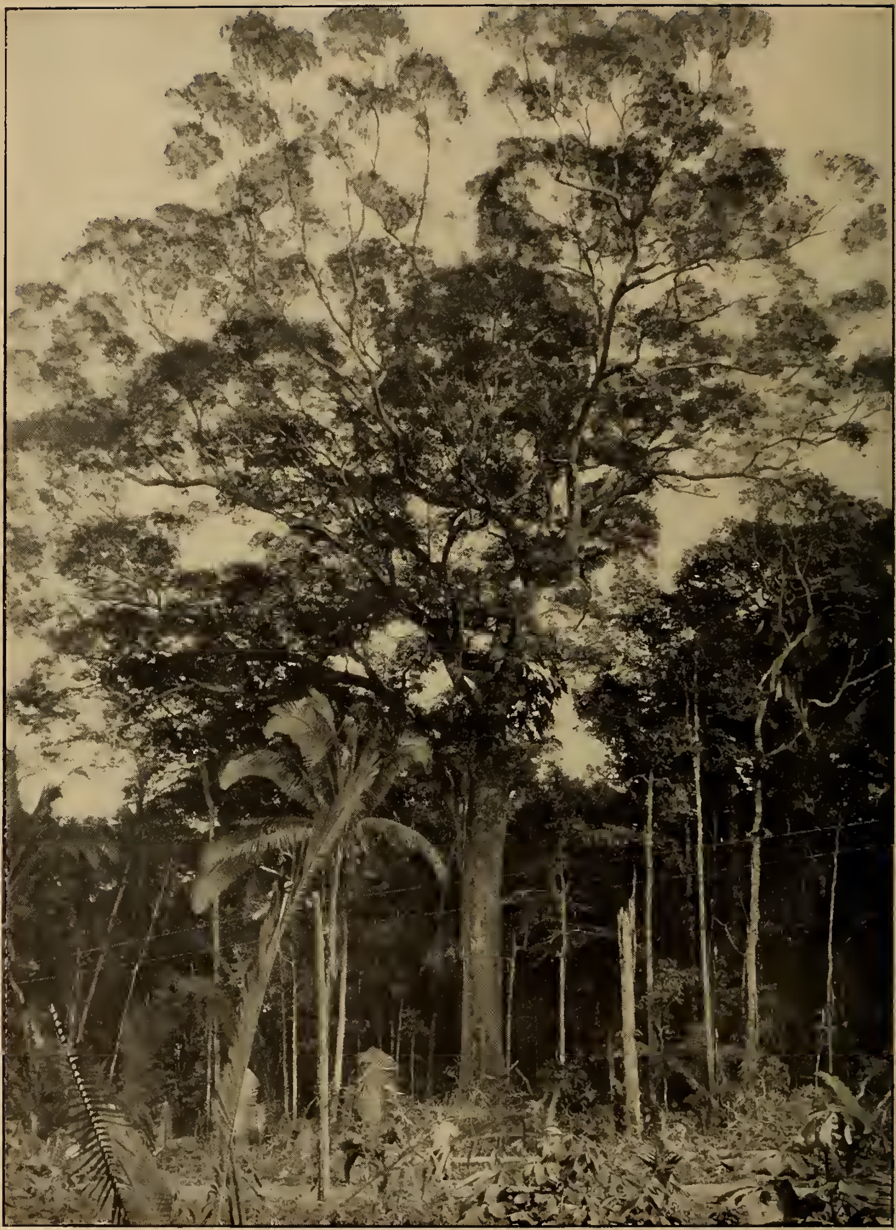
A further extension of this line has been granted by the bill of 1909, this covering a branch from Independencia to Bananeiras.

North of Independencia the State of Rio Grande del Norte is soon reached. A line was built from

A CASCADE IN THE FOREST

Natal, its capital, southward to Nova Cruz, between the years 1881 and 1883. This line, the Natal and Independencia Railway, has been joined to the northern extremity of the Conde d'Eu Railway since 1904; its length is 107 miles.

The Great Western system ceases in Natal. Another line starts from Natal and runs straight inland. This is the Northern Rio Grande Central Railway, extending from Natal to Ceara Mirim and Caico (or Jardin), on the Sirido River. This line is



CLEARING THE WAY FOR RAILWAY CONSTRUCTION

open to Taipu, a distance of thirty-five miles; the remaining 153 miles are still under construction, but as soon as a sufficient length is ready there seems to be no doubt that the Government will hand the line over to the Great Western Railway, as was done with the Central Pernambuco Railway.

The northern group carries sugar and cotton in large quantities, as below:

	Sugar, Tons.	Cotton. Tons.
Conde d'Eu Railway..................	2,206	14,864
Recife, Limoeiro and Timbauba Ry.	16,153	12,857
Natal and Independencia Railway....	853	1 331

STEAMBOATS AT ANCHOR ON THE AMAZON

THE GREAT WESTERN SYSTEM.

The Great Western is not yet a system, properly speaking; it is still a number of separate lines that have been joined together owing to the Great Western having brought them all into the same hands. It is more than doubtful whether these links would have been built otherwise; the number of years that went by without their having been taken in hand before the Great Western unification, is sufficient proof of this, a fact clearly shown by the above table.

GREAT WESTERN SYSTEM.

Section of Through Line.	Opened in	Gap Southward Between	Miles.	Spanned.
Natal-Nova Cruz	1883	Nova Cruz-Independencia	32	1904
Independenc a-Pilar	1883	Pilar-Timbauba	25	1901
Timbauba-Recife	1881–1882	Around Recife	9	1907
Recife-Uno (Palmares)	1858–1862	Nil	Nil	
Uno-Glycerio	1882–1887	Glycerio-Uniao (Imperatriz)	30	1894
Uniao-Jaguara-Atalaya	1884	Atala a-Propria	310	Surveying.

Most of the lines making up the system were built in the early eighties and three miserable stretches of thirty miles in length were left out for ten and even twenty years, merely because they happened to lie between the terminals of two separate companies.

to these the metre and the 5 foot 3-inch broad gauge, we come to the astounding total of eight different gauges in this single State, namely: 2 ft. 5½ in. (0.75 m.); 2 ft. 6 in. (0.76 m.); 3 ft. 3⅜ in. (1 m.); 4 ft. (1 m. 20); 4 ft. 7 in. (1 m. 40), and 5 ft 3 in. (1 m. 60). This is interesting, but hardly practical.

Of the three groups composing the Great Western system, the Central is the best. The results of operation in 1907 were:

	Earnings.	Expenses.	Net Earnings.	Ratio. %
Southern group	£196,073	£124,169	£71,944	63.1
Central group	85,769	50,657	35,112	59.1
Northern group	142,525	104,120	38,405	73.0
Total, three groups	£424,367	£278,966	£145,401	65.7

The following table shows the expenses per mile and the traffic of each of the groups:

Group.	Passenger Miles.	Ton Miles.	Expenses Train Mile.		Expenses per Mile.		Mileage
South	14,248,399	13,998,366	67*d*	92	£401	14*s*	311 miles.
Central	8,515,394	4,372,000	63*d*	52	318	17*s*	142 "
North	9,048,390	7,503,946	76*d*	70	312	3*s*	329 "

Nor is this the only important mistake that was made. A number of lines have been granted by the State of Pernambuco to various private companies, still independent concerns, and all of them, except one, are laid to a different gauge, clearly showing the short-sightedness of Stadoal policy as compared with that of the Government. Thus the Ribeiarao-Barreiros line is 36 miles of 2 foot 6-inch gauge; the Santos-Diaz line is 16 miles of 2 foot 5½-inch gauge; the Cachoeira-Liza line is 16 miles of 2 foot 5½-inch gauge; the Recife and Caxanga line is 16 miles of 4-foot gauge, and the Recife-Olinda and Berebibo line is 15 miles of 4 foot 7-inch gauge. If we add

The Paulo Alfonso Railway is not included in the above table. For the Alagoas Central, Pernambuco Central and Conde d'Eu railways the Great Western pays rentals. The total in 1907 amounted to £18,123. The special tax called fiscalization tax is due on all lines; it amounted to £3,770.

Though the system is still isolated, connection with the northern lines will be established through the Pernambuco Central Railway, and with the Bahia system through the Timbo and Propria line and Atalaya extension, 309 miles, inclusive of the 94 miles of extensions. The Sao Francisco River will be crossed in barges, or perhaps by steam ferries,

AN OX TEAM AT WORK IN THE BRAZILIAN FOREST

between Propria, on the southern bank and Collegio on the northern.

Two branches will be built at the same time. Work has been started, and there is no doubt about the usefulness of the line, the missing link to be bridged by the South Bahia Railway, establishing the only remaining connection not yet opened to traffic between Rio and the northern States. The Great Western Railway has no river navigation to compete with, though freight, of course, travels along the coast parallel to its

main line. In fact, there is no navigable river in the whole region, but the southern boundary along the Sao Francisco River makes up for this deficiency.

The Sao Francisco River takes its source in the State of Sao Paulo, under the 21st degree of latitude, becomes navigable near the 20th and almost reaches the 8th in its flow northward; an unbroken waterway to the sea, with a single interruption, spanned by the Paulo Alfonso Railway.

The southern limit of navigability is reached by two railroads, the Central of Brazil, at Pirapora and the West of Minas Railway at Paraopeba. There is a further rail connection at Joazeiro, above Pecanha, from whence a railway line leads straight to Bahia and carries off a notable portion of the river traffic. A number of the tributaries of the Sao Francisco are navigable, but such navigability will really be useful only when it will form through channels of communication. None of the coast railways has reached these tributaries, nor is any railway likely to reach them for some time to come.

The Upper Sao Francisco Navigation Company owns thirteen steamers and ten launches, and in consideration of a subsidy of £9,374, it is required to run two monthly trips up the river and its tributaries. In 1907 sixty-seven trips were made, aggregating 63,556 miles, carrying 4,358 passengers for £5,159 and 4,885 tons of goods for £12,796. The steamers range from 75 tons (65 registered) down.

The traffic on the lower Sao Francisco is sufficient to warrant competing lines. The Pernambuco Company runs four steamers of 32, 67, 207 and 240 tons, plying up the river; the Lower Sao Francisco Company operates two more steamers, and both companies draw a subsidy, one receiving £10,250 and the other £3,250 per annum.

The coast traffic is catered to by several companies, the Brazilian Lloyd being the foremost. None of the harbors is of much value. Out of 159 steamers which visited Natal in 1907, six only were not Brazilian.

Parnahyba is in the hands of an improvement commission and Recife is undergoing a thorough alteration. The works are in the hands of a French company; it is the intention to convert the harbor into a first-class one for accommodating vessels of the deepest draught. It should be remembered that Recife is the nearest of all Brazilian ports to the old world and it is bound to come in for a large share of traffic. In 1907, as it is, it was visited by 1,273 steamers and sailing vessels, aggregating 1,459,418 tons. Sharp competition is bound to take place between Recife and Bahia and both of these ports will have fine harbors in the near future.

TABLE OF THE LINES NOW FORMING THE GREAT WESTERN RAILWAY SYSTEM.

Line.	Miles.	Building.
Paulo Alfonso Railway:**		
Jatoba to Pirahans	72	
Alagoas Central Railway:**		
Jaguara to Uniao	55	
Vicosa Branch	39	
Vicosa Palmeira, extended branch	...	About 40.
Pernambuco Southern Railway:**		
Una (Palmares) to Garahuns	91	
Glycerio to Uniao	30	
Recife and Sao Francisco Railway:**		
Recife (Pernambuco) and Una	78	
Ribeirao and Cortez Branch:**		
Rebeirao to Cortez	18	
Cortez to Bonito	...	21 granted.
Pernambuco Central Railway:**		
Recife to Pesqueira	143	
Pesqueira to Flores	...	About 150.
Tigipio to Camargibe, loop	6	
Areia Boa Viagem, loop	4	
Recife Limoero and Timbauba Railway:		
Recife to Limoero*	51	
Carpina and Timbauba*	36	
Timbauba to Pilar**	18	
Itabayana Campina Grande**	50	
Conde d'Eu Railway:**		
Pilar to Cabedello	48	
Alagoa Grande Branch	15	
Junction to Independencia	41	
Independencia Bananeiras Branch	...	About 30
Natal and Independencia Railway:**		
Natal to Independencia	107	

* Lines conceded by the government of the Union, without guarantee of interest.

** Lines belonging to the government of the Union, and eased to the Great Western Railway.

(To be Continued.)

MODERN CAR-WHEEL TURNING

By Walter L. Clark

THE enormous railway mileage in the United States and the high price of skilled labor have had the effect for many years of developing anything to do with the mechanical equipment to a very high point of efficiency. This is becoming better understood year by year, so that countries in parts of the world where railroad development has not been very great are turning more and more to America for standards of equipment, especially in the necessary machine outfit for maintaining rolling stock.

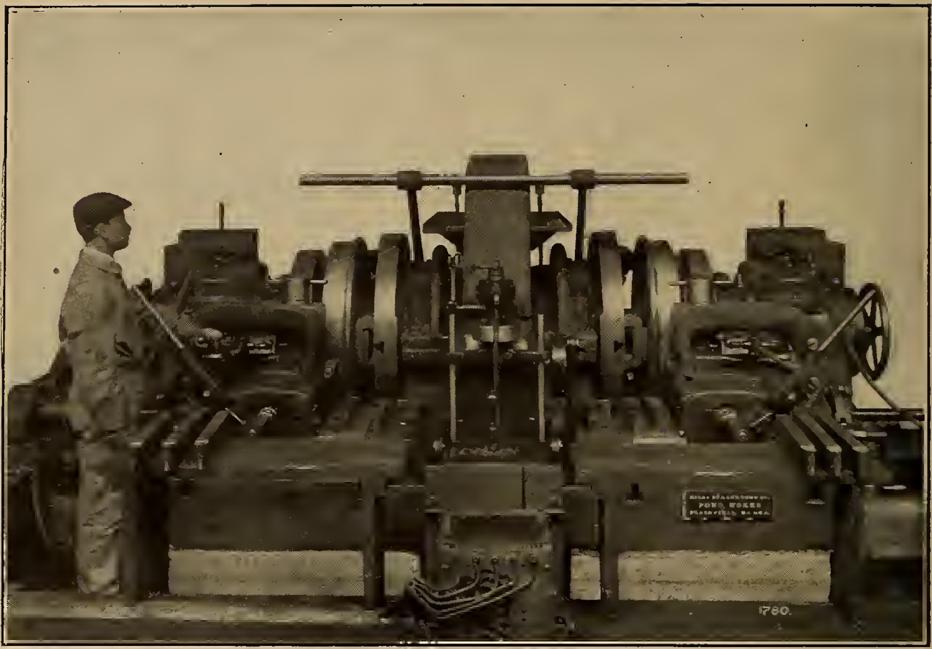
The work of repairing locomotives and cars is of such a diversified nature that it is sometimes difficult to point out specific instances of advantage of American machine tool equipment over that in use in the older and smaller countries of Europe.

A recent case, however, has come to the writer's attention, where a parallel can be fairly drawn which, we think, will be of some interest to your readers. In the issue of *Cassier's Magazine*, March, 1910, in an article entitled "Tramway Repair Works and Machinery," a car-wheel turning lathe constructed by an English builder is illustrated and described. The writer states that the steel used for car wheels being hard, and the skin constantly made harder by rolling on the rails, together with the friction of the brakes, makes it impossible for an ordinary wheel lathe to turn these tires in a reasonable time, taking as long as 8 to 10 hours to turn a pair, even when using the best high-speed steel, the chatter due to want of rigidity in the lathe causing the tools quickly to lose their cutting edge.

The machine illustrated, he states, has been designed to meet this difficulty, the new lathe having an average output of six pairs of wheels per day.

I think it will be safe to say that the output of the best American lathes averaged six pairs of wheels per day fully ten years ago, and no particular point was made of it. This was when using tool steel of the ordinary variety. Since the advent of the high-speed tool steel the designers of the United States have brought up their machine tools from year to year to a constantly higher state of efficiency, until the best lathes were probably averaging 12 pairs of wheels per day five years ago. Within the past two or three years this output has been steadily increased by improvements in design and methods of handling, until at the present time many railroads are equipped with lathes turning out from sixteen to twenty pairs of 36-inch wheels in ten hours, these outputs being readily obtainable with tires of all the standard makes of England, Germany and America.

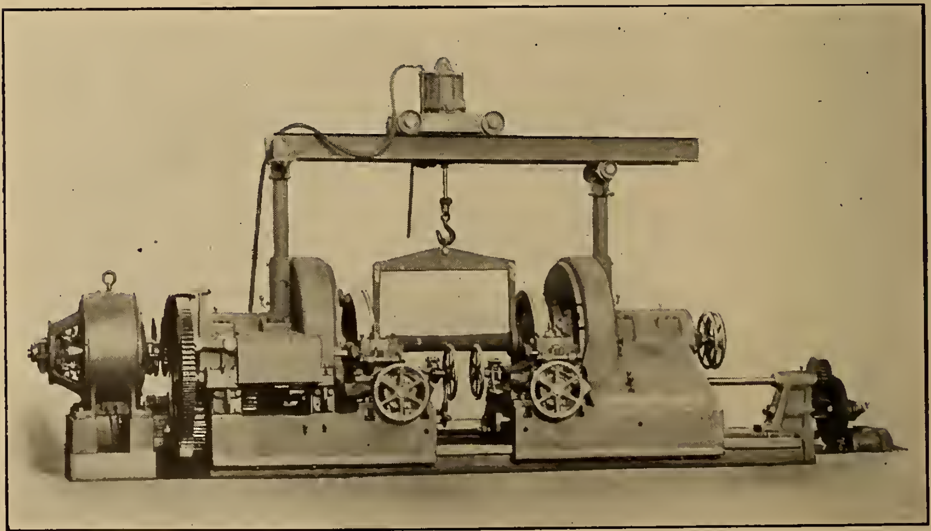
The latest report we have seen in which a detailed record has been kept of tire turning, is one from a day's run on a Niles-Bement-Pond wheel lathe at the West Albany shops of the New York Central & Hudson River Railroad. We are informed that the tires on these wheels were about equally divided between an American make and those turned out by Messrs. Krupp. We are further informed that the work was done by



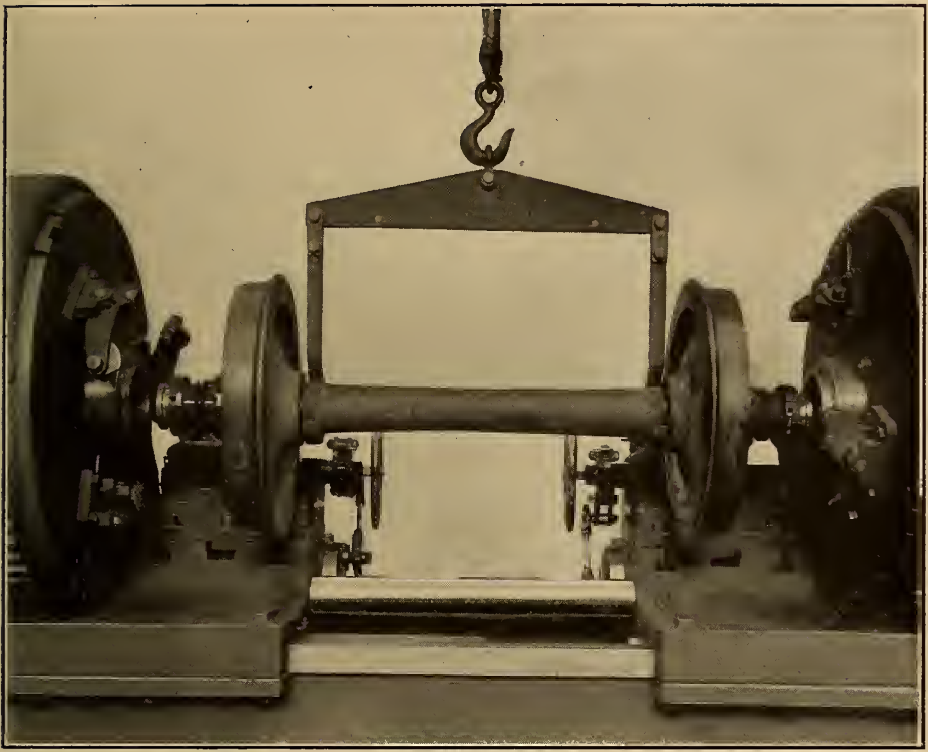
CAR-WHEEL LATHE. NILES-BEMENT-POND CO., NEW YORK. ON THIS LATHE 33 PAIRS OF WHEELS WERE TURNED IN 9 HOURS AND 53 MINUTES

the ordinary railroad shop workmen. It will be noted that thirty-three pairs of 36-inch wheels were turned in 9 hours and 53 minutes, being an average of 17 minutes and 58 seconds per pair.

Another statement comes to us of a test made by Messrs. William Sell-



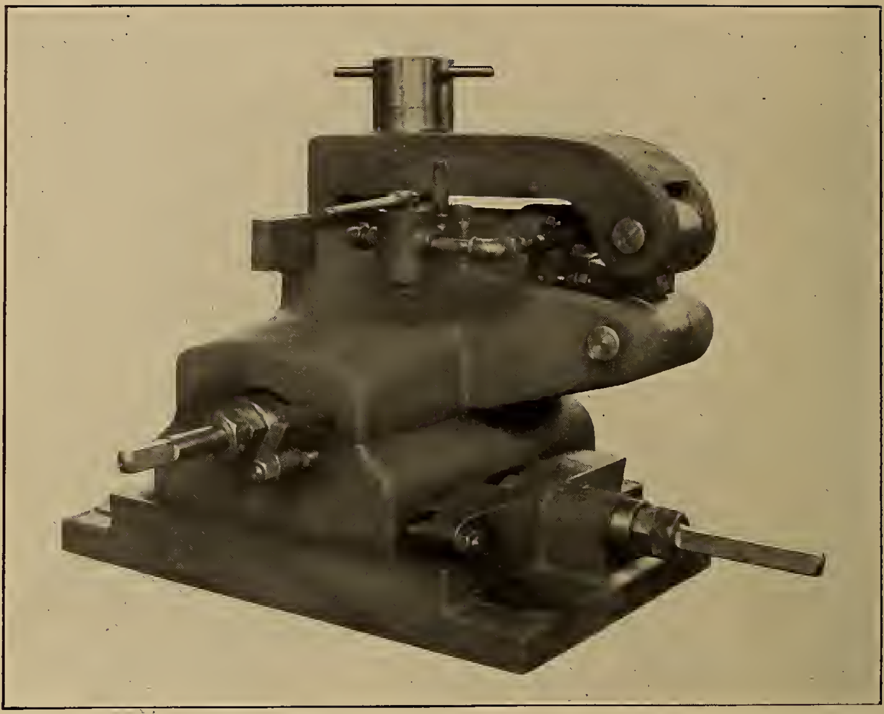
CAR-WHEEL LATHE. WILLIAM SELLERS & CO., INC., PHILADELPHIA. ON THIS LATHE SIX PAIRS OF WHEELS WERE TURNED IN 2 HOURS AND 11 MINUTES



SELLERS CAR-WHEEL LATHE, SHOWING HEADS AND DRIVING DOGS

ers & Company, Inc., in their own shop, in which one of their lathes turned six pairs of 36-inch wheels in 2 hours and 11 minutes.

Wheel lathes in the United States were gradually increased in weight and power until it was finally found that the wheels and axles themselves were the weak point in the turning operation. Recognizing this fact Messrs. Small & McNaughton, well known railroad engineers, brought out about twenty years ago a design of a machine to overcome this difficulty. This lathe at that time was quite a radical departure from the ordinary design. The turning of the axles on centers was abandoned, the entire axle journal being received in the head by means of a split bush made to fit the axle, and having its exterior turned taper. This eliminated the obvious weakness and hence springing of the center and its projecting spindle; it held the axle rigidly close up to the wheel. The old form of wheel lathe was driven from one end and the power carried across the machine by a long shaft. This put an inevitable amount of torsion and lack of rigidity between the point at which the power was applied, and the wheel to be turned at the other end of the axle, and it was found to be one serious source of vibration and chatter. To overcome this difficulty the Small & McNaughton design was driven by a large spiral gear in the center, having a gap through which the axle could be rolled. The power from this large central drive was furnished to each wheel through face plates. The outside spindles supporting the axle were also provided with face-plates and chucks, hence the wheels were clamped rigidly between two staunch face-plates, driven from one and chucked by the



POND PNEUMATIC TOOL CLAMP

other; thus the wheels were held with absolute rigidity and became, in fact, one with the machine itself.

On a modern wheel lathe no attention is paid to the hard skin of the tire caused by friction of the wheels and brake-shoes, for the simple reason that the tool is put directly under this scale and a heavy roughing cut can be fed across in eight or nine minutes. After that a finishing tool is used the full width and shape of the tread, and fed directly in without any use of cross-feed, a third tool the shape of the flange finishing the operation.

The more recent lathes show no very marked improvement in general design, the increased output coming from great weight and power and improved facilities for handling, and getting the wheels in and out of the lathe, and from the higher quality tool steel.

After the capacity of the wheel lathe got up to twenty or more pairs of wheels a day, the manual labor of clamping and unclamping the cutting tools became quite a serious matter for the operator, and a number of devices have been brought out to lighten and quicken this operation. The limit of human endurance comes into the problem, and where clamping and unclamping had to be done with a wrench on, say, twenty pairs of wheels per day, it would mean 350 to 400 manipulations in ten hours.

One device that has been brought out is in the form of a turret toolholder, which has the roughing and finishing tools set in it, the holder being rotated to bring the various forms into action.

Another device which is illustrated in this article is a pneumatic clamp by which the operator simply opens a compressed air valve and clamps his tool by power. In this arrangement the air cylinder is built in the body of the tool rest; the piston carries a wedge, which, operating between two

DATA OF TEST OF NILES-BEMENT-POND CAR-WHEEL LATHE.

POND 42-INCH MOTOR-DRIVEN CAR-WHEEL LATHE
AT WEST ALBANY CAR SHOPS, N. Y. C. & H. R. R.R. 36-INCH KRUPP AND PAIGE WHEELS, MAY 11, 1910.
CONTINUOUS RUN FROM 7 A. M. UNTIL 5:53 P. M., ONE HOUR FOR NOONING.

Pair No.	1	2	3	4	5	6	7	8	9	10	11	Average.
Putting in lathe	3	2	2	3	2	2	2	3	2	3	2	2 min., 28 sec.
Roughing	11	8	9	9	9	9	9	9	11	10	10	9 min., 23 sec.
Finishing	5	6	4	3	5	4	6	4	7	5	5	5 min., 7 sec.
Taking out	1	1	1	1	1	1	1	1	1	1	1	1 min., 0 sec.
Time from floor to floor	20	17	16	16	17	16	18	17	21	19	18	17 min., 58 sec.
Depth of cut	1/4	1/8	3/16	1/4	3/16	1/8	1/8	3/16	3/16	1/4	3/16	3/16 inch.
Feed	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32 inch.
Speed	16	16	17	15	14	12	13	18	12	14	15	14.4 feet.

Pair No.	12	13	14	15	16	17	18	19	20	21	22	Average.
Putting in lathe	2	4	2	2	2	4	3	2	2	3	3	2 min., 28 sec.
Roughing	9	11	12	8	9	8	10	8	9	9	11	9 min., 23 sec.
Finishing	5	5	8	4	5	4	6	7	5	5	6	5 min., 7 sec.
Taking out	1	1	1	1	1	1	1	1	1	1	1	1 min., 0 sec.
Time from floor to floor	17	21	23	15	17	17	20	18	17	18	21	17 min., 58 sec.
Depth of cut	1/8	3/16	1/2	1/8	3/16	3/16	1/8	1/4	1/4	3/16	3/16	3/16 inch.
Feed	13/32	13/32	5/16	13/32	13/32	13/32	3/32	13/32	13/32	3/32	3/32	13/32 inch.
Speed	15	13	10	14	12	15	11	12	10	14	12	14.4 feet.

Pair No.	23	24	25	26	27	28	29	30	31	32	33	Average.
Putting in lathe	2	3	2	2	3	3	3	3	3	1	1	2 min., 28 sec.
Roughing	9	11	9	10	7	10	9	10	10	7	10	9 min., 23 sec.
Finishing	5	6	5	6	5	6	5	4	3	5	5	5 min.. 7 sec.
Taking out	1	1	1	1	1	1	1	1	1	1	1	1 min., 0 sec.
Time from floor to floor	17	21	17	19	16	20	18	18	17	14	17	17 min., 58 sec.
Depth of cut	1/4	3/16	1/8	1/8	3/16	1/4	3/16	3/16	1/8	3/16	1/4	3/16 inch.
Feed	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32	13/32 inch.
Speed	14	13	11	14	20	15	17	17	16	21	18	14.4 feet.

AVERAGE TIME FOR TURNING, 17 MIN., 58 SEC. TOTAL TIME FOR 33 PAIRS, 9 HOURS, 53 MIN.

rollers as shown, forces up the long end of the clamping lever; thus the operator is relieved from several hundred strenuous muscular exertions, leaving him more efficient to attend to the actual turning operations.

Without going into the details of the matter, the driving wheel turning has been improved on the same basis of reasoning, viz.: to hold the work rigidly in the machine, so that springing away from the tool and chattering will be prevented.

A few years ago one to two pairs of 84-inch driving wheels a day was considered a normal output; now with modern American machines many shops are turning out from six to ten pairs in ten hours.

The economy to the Railroad Company by the use of these wheel turning machines alone will be readily appreciated. In a recent visit to a European government railroad shop, the writer saw a wheel lathe running at a very low speed and very fine feed, and inquired of the operator what the output of the machine was. The reply was that he was turning one pair of 48-inch wheels every three days. This, of course, was an extreme case, but we believe it will be found to be a fact that to turn a pair of 84-inch driving wheels in ten hours will be considered a fair day's work in most any Continental or British railroad shop.

We believe it to be a demonstrable fact that the output per man in an American locomotive works is fully double what it is in England. It is a common thing to find machines working in English shops that have been there for twenty-five or thirty years, during which period in almost any American shop at least two generations of tools have passed away.

We have become accustomed to general statements of this character, but in the present instance of wheel turning we have a clean-cut case, which must be met somehow. Is it a fact, or is it not?

According to the article we have referred to, the output per lathe in England is from three to six pairs of wheels per day. In America the output per lathe is from twelve to twenty-five per day. There are many thousands of wheels being turned yearly by the English railroads, and

the cost in hours of labor is about four times what it should be.

If there is any doubt about this the evidence is at hand. Furthermore, we believe this same deadly parallel runs through most of the other tools in the shop, and additional comparisons will be of much interest.

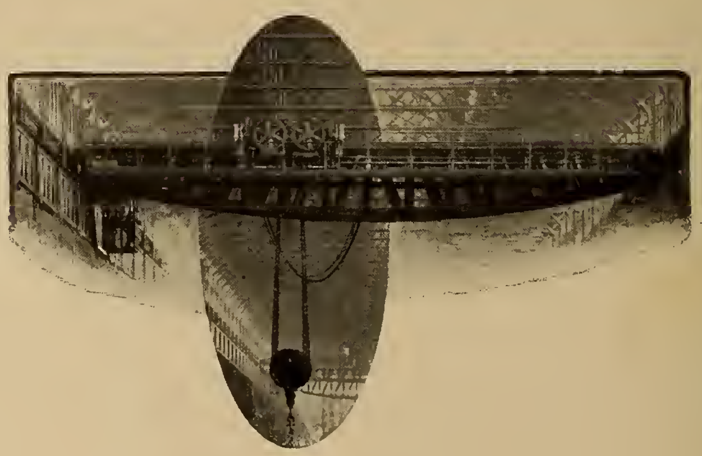
Several years ago a statement was published by one of the largest locomotive builders in Great Britain that with about 14,000 men their output was six hundred engines per year. At that very time the output of the same number of men in America was 1,800 engines a year, or three to one. An answer might be made to this statement that the British-built engine is better finished than the American, and to avoid argument this could be admitted and there would still be 100 per cent. or two engines to one to be accounted for.

It is particularly to be noted that this comparison is in hours of labor, with no uncertainties of cost to burden the reasoning.

Similar improvements have been made in American tools for the other leading operations on a locomotive, such as boring cylinders, machining side-rods, turning axles, boring wheels, etc. This cannot be taken up in detail at this time.

The American locomotive shop is open. "Visitors are welcome!" This is practically over each door.

How is it that a leading English firm can put upon the market a new machine with a quoted capacity nearly two decades behind the times?



THE PROPULSION OF CARGO BOATS

AN INVESTIGATION AS TO THE BEST SYSTEM OF PROPULSION IN VIEW OF RECENT DEVELOPMENTS IN ENGINEERING.

By R. M. Neilson, M. I. Mech. E.

RECIPROCATING ENGINES

WHAT may be called the standard propelling machinery for cargo-carrying steamships at the present day comprises return fire-tube boilers and reciprocating triple-expansion or quadruple-expansion engines. The steam pressure is usually between 160 and 200 pounds per square inch.

The present type of machinery has been gradually evolved, improvements having been continually made and steam pressures raised. The latest improvements of importance have reference to the condensing plant.

Figs. 1 and 2 illustrate a typical set of cargo-boat engines, except that the condenser, which is of the Contraflo type, is smaller than has usually been employed until recently. These engines are of the triple-expansion type and of about 1,400 indicated horse-power, and have been built for a single-screw vessel and for a steam pressure of 180 pounds per square inch above atmosphere. The high-pressure cylinder is fitted with a piston valve and the intermediate and low-pressure cylinders with double-ported slide valves, the valve gear being of the ordinary link-motion design. A steam reversing engine of the "all-round" type is provided. The cranks are built up, and the crankshaft is in three interchangeable pieces. The round front columns, as well as the square back columns, are of hollow cast iron, and the bedplate is of the same material. The engines have been built at the Hartlepool works of Messrs. Richardsons, Westgarth & Co., Ltd.

The economy now obtainable with cargo-boat machinery is so high that there seems little prospect of substantial improvement, unless by some radical change; and in considering possible alternatives to the present machinery of propulsion one must bear in mind that initial cost is a very important item. Moreover, in the case of vessels which may have to travel all over the seas it is desirable that complicated, little-understood or unpopular machinery should be avoided unless capable of showing some very good reason for its adoption.

As regards the boiler room, water-tube steam generators offer opportunity for reduction of weight, and therefore reduction in a vessel's displacement for a given cargo-carrying capacity; but unless water-tube boilers can be sold at a price little in excess of that accepted for fire-tube boilers and can be so constructed that their cost of maintenance is not materially greater than that of fire-tube boilers, no financial benefit can, as a rule, be expected from their adoption in a low-speed cargo boat, in which a slight reduction in displacement and engine power, such as could be obtained by a reduction in the boiler-room weights, does not represent a great difference in the cost of the hull.

As regards the engine room, many schemes for the employment of machinery to replace the present type of reciprocating engines have lately been proposed; but, before dealing with these, it will be convenient to refer to a means which offers a chance of substantial improvement in

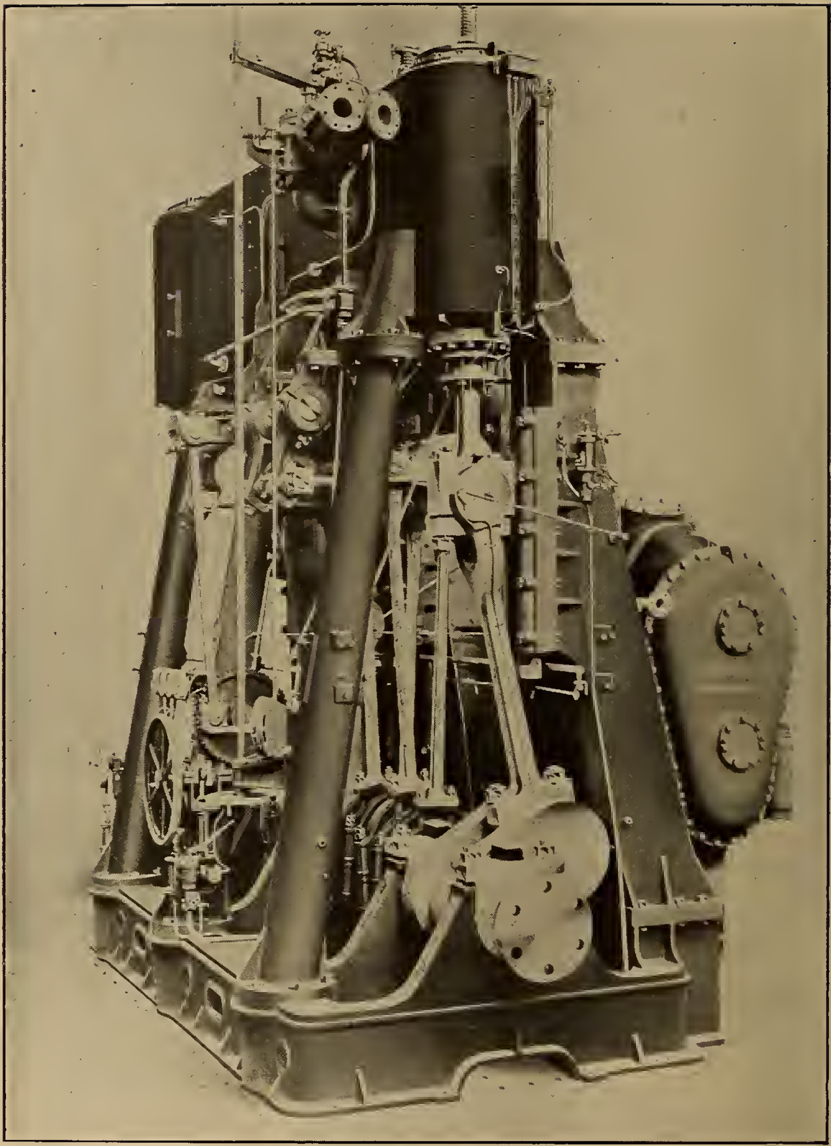


FIG. 1.—TRIPLE-EXPANSION MARINE ENGINE. RICHARDSONS, WESTGARTH & CO., LTD.

economy without calling for great alteration in the present engine-room machinery—namely, the employment of superheated steam.

SUPERHEATED STEAM FOR RECIPROCATING ENGINES

Superheated steam, as is well known, was employed to a considerable extent and with good results in reciprocating marine engines in the middle portion of the last century, when steam pressures were low and fuel consumption high; but the results obtained with these early superheaters, which necessarily worked under conditions differing greatly from present-day practice, are of little service in solving the problem as

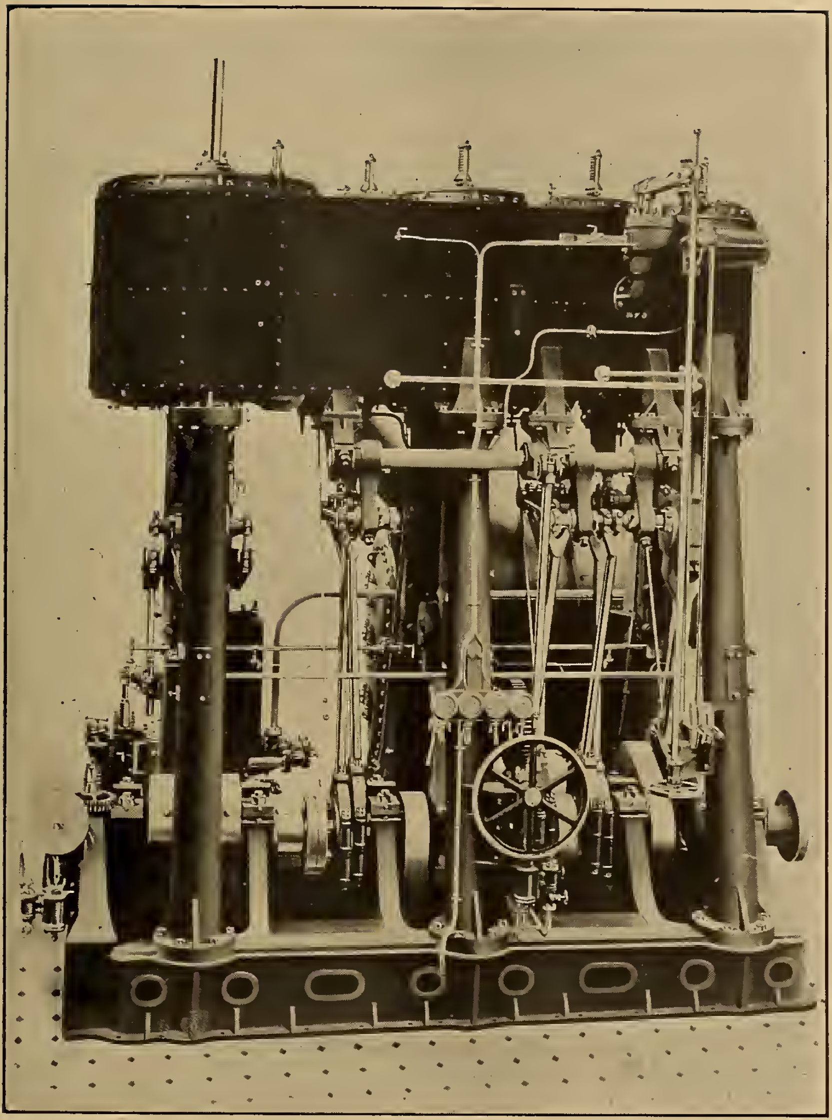


FIG. 2.—TRIPLE-EXPANSION MARINE ENGINE, SAME AS FIG. 1

to the advisability of employing superheaters in modern cargo boats.

In recent times, however, attempts have been made to employ superheated steam with reciprocating engines both on land and at sea; and it may be said that in every case the adoption of superheating has led to a reduction in coal consumption, although there is some difference of opinion as to whether a real increase in economy, considering all things, has been attained. Even if this question is settled, as it probably soon will be, in favour of superheating, there remains the objection as regards tramp steamers that the employment of superheated steam calls for more careful handling of both boilers and engines than is often accorded to the propelling machinery of these vessels; and anything which

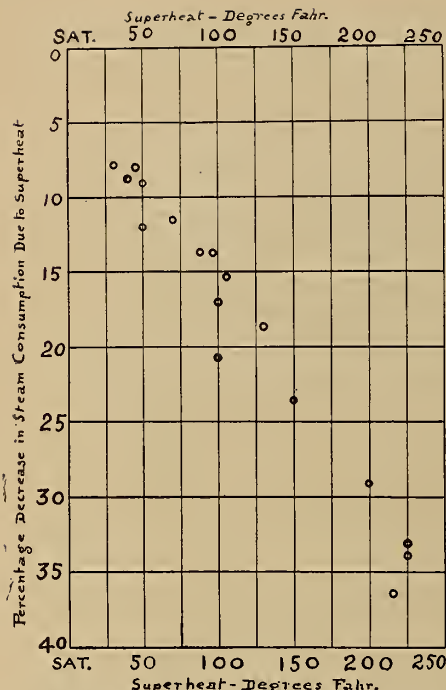


FIG. 3.—EFFECT OF SUPERHEAT ON STEAM CONSUMPTION OF RECIPROCATING ENGINES. RESULTS OF VARIOUS TESTS.

appears to increase complication or risk of breakdown is generally looked on with disfavour by the ship owner.

Many tests might be quoted to show the reduction in steam consumption effected by superheating. Allowing for a certain number of inaccuracies of measurement, these tests are in very good agreement. One set of tests only will be given by way of example, and this set will show not only what reduction in steam consumption is obtainable by superheating, but will also show that small inaccuracies in measurement are to be expected. The tests in question were made by Dr. D. S. Jacobus last year on the engines of the steam yacht *Idalia* under service conditions. The yacht has four-cylinder triple-expansion engines 11½ inches, 19 inches, 22 11/16 inches and 22 11/16 inches in diameter by 18-inch stroke.*

The results of the tests are given in Table I. The figures in the last three lines of the table were calculated by the writer, the mean specific heat of the steam being taken as 0.6. The steam consumption was obtained by Dr. Jacobus by weighing the water of condensation; and it will be seen that a superheat of 105 degrees F. reduces the steam consumption about 15 per cent. No attempt was made to measure the coal consumption, and it is questionable if any useful result would have been derived from such measurement, as the boiler was designed to supply superheated and not saturated steam, the designed superheat being 100 degrees F. The last line in the table supplies the required information as to the reduction in coal consumption to be expected from superheating, assuming the efficiency of the boiler to remain constant.† The difference in the hot well temperatures will not affect the results more than one-half of one per cent. The results are a little irregular; the irregularity is

TABLE I.

S. Y. *Idalia*. STEAM CONSUMPTION WITH SATURATED AND SUPERHEATED STEAM.

Date, 1909	Oct. 11	Oct. 14	Oct. 14	Oct. 12	Oct. 13
Degrees Fahrenheit of superheat	0	57	88	96	105
Steam pressure at throttle, pounds per square inch, abs	190	196	201	198	203
Vacuum, inches of mercury*	25.5	25.9	25.9	25.4	25.2
Hot well temperature	116.0	109.5	115.0	111.5	111.0
Revolutions per minute	194.3	191.5	195.1	191.5	193.1
Indicated horse-power	512.3	495.2	521.1	498.3	502.2
Water per hour, pounds	9,397	8,430	8,234	7,902	7,790
Water per I. H. P. per hour, pounds	18.3	17.0	15.8	15.8	15.5
Heat in steam consumed per I. H. P. per hour, B. T. U.	20,400	19,650	18,460	18,600	18,370
Per cent reduction in steam consumption per I. H. P. per hour	0	4.6	13.7	13.7	15.3
Per cent reduction in heat consumption per I. H. P. per hour	0	3.7	9.5	8.8	10.0

* It is presumed that the vacuum has been corrected either for a 29.92 inch or a 30-inch barometer.

* The particulars of the engines of the *Idalia* and of the tests by Dr. Jacobus mentioned abcve have been taken from the Journal of the American Society of Naval Engineers, November, 1909.

† Speaking generally, the efficiency of boiler plus superheater may be either greater than, equal to, or less than, the efficiency of boiler alone, according to the boiler and superheater design and arrangement.

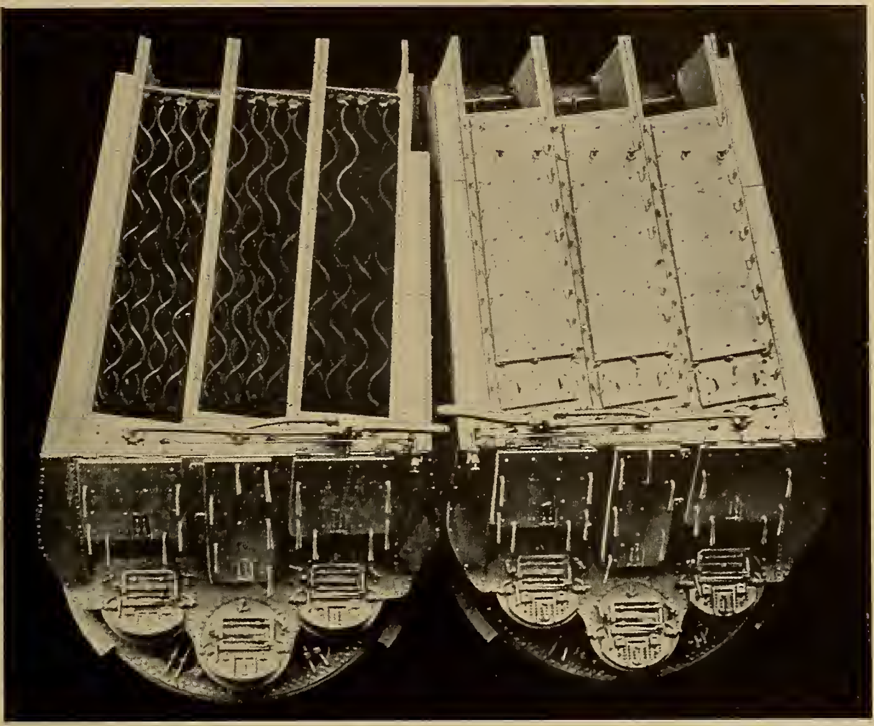


FIG. 4.—CENTRAL SUPERHEATER FITTED TO MARINE BOILERS

only partly accounted for by the variation in the vacuum and must be further accounted for by inaccuracies of measurement; but the results show that a reduction of about 9 or 10 per cent. in coal consumption can be expected from a superheat of 100 degrees F.

In Fig. 3 the points show the results of independent tests made by different engineers at various times on reciprocating engines, and give an idea of the percentage reduction in steam consumption which may be expected from employing superheated steam. The discrepancy in the results is accounted for, in the first place, by the engines being of different types and sizes, in the second place by inaccuracies of measurements, and, in the third place, by the fact that in some cases the comparison was made with dry, saturated steam, while in other cases the saturated steam contained water which was reckoned as steam.

MARINE SUPERHEATERS AT PRESENT IN USE

The Central Marine Engine Works, West Hartlepool, have in recent years fitted superheaters to several vessels. In 1891 a superheater or "steam dryer" was fitted on board the steamship *Elmete,* owned by the London & Northern Steamship Company. A few years later the steamship *Inchmona* was fitted with a superheating installation by the same company with five-crank quadruple-expansion engines and a boiler pressure of 255 pounds. The *Inchmona* installation gave such encouraging results that the *Inchdune* and *Inchmarlo,* built for the same owners in 1900, were provided with an improved arrangement of superheater by the same makers and proved very economical of coal in service.

Fig. 4 shows the arrangement of "Central" superheaters as applied to marine return-fire-tube boilers, and Fig. 5 shows the same arrangement

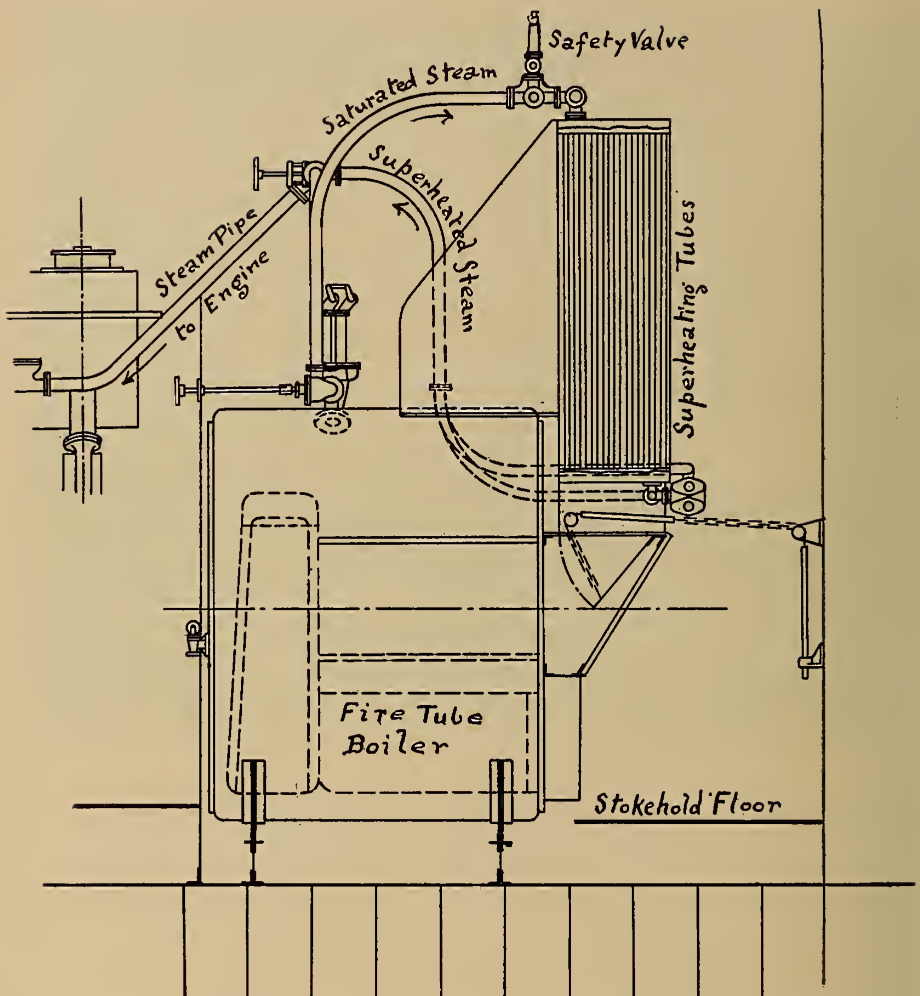


FIG. 5.—ARRANGEMENT OF CENTRAL SUPERHEATER AS FITTED TO A MARINE BOILER

with the pipe connections. It will be seen that the superheating tubes are of a wavy nature, these tubes being arranged in three parallel sets. Each set connects a top header with a bottom header. The saturated steam is led to the top headers and passes from the lower headers to the engine. Superheaters of this nature were fitted on the *Inchdune* and *Inchmarlo* above referred to, and it may be interesting to give some particulars of the installation in one of these vessels. In the *Inchmarlo*, for example, the boilers and superheaters were designed for a working pressure of 267 pounds and a superheat of about 70 degrees. The cylinders are of the five-cylinder, five-crank, quadruple-expansion type, with the first intermediate, second intermediate and two low-pressure cylinders steam jacketed. The following temperatures were measured in a test made on October 26, 1900:

On deck	53	degrees Fahr.
In stokehold	77½	" "
Hot gases entering superheater	587	" "
Hot gases leaving superheater	543	" "
Steam at inlet to superheater	412	" "
Steam at exit from superheater	469½	" "
Steam at high pressure steam chest	447	" "

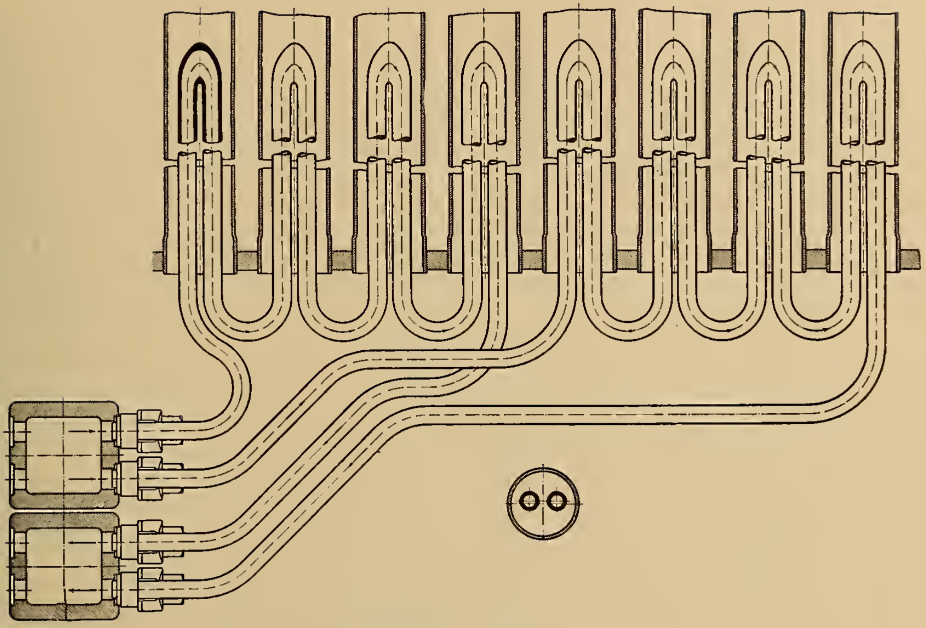


FIG. 6.—SCHMIDT SUPERHEATER AS APPLIED TO A FIRE-TUBE BOILER

The Schmidt system of superheating steam has been applied to a very large number of vessels belonging chiefly to continental companies or governments. The power of the vessels to which the Schmidt system has been applied varies from 100 horse-power to 15,000 horse-power; and the ships include cargo boats, passenger steamers, tugs and warships. In the Schmidt system, as applied to marine return-fire-tube boilers, superheater pipes are led to and fro within the fire tubes as shown in Fig. 6. These superheater pipes lead from, and return to, headers which are usually arranged vertically across the front of the boiler, as shown in Figs. 6, 7, 8 and 9. The headers are arranged in duplicate, one header to convey the saturated steam to the superheater tubes and the other to convey the superheated steam to the main steam pipe to the engines. It will be seen in Fig. 6 that the steam passes through several fire tubes in series. The ends of the superheater pipes, where they join the headers, are provided with a collar which can be clearly seen in Figs. 6 and 7. The collars are for jointing purposes, and each is held in place by a cast-steel dog secured by a single bolt. If one of the superheater pipes should leak, or if for any reason it should be desired to remove this pipe, this can be accomplished by unscrewing two nuts, one securing the dog at the inlet end of the pipe and the other the dog at the exit end. The defective pipe can then be removed and stoppers placed in the holes, and the boilers continue steaming with the single element removed. The superheater and boiler tubes are usually cleaned by means of steam jets.

Some particulars of the steamship

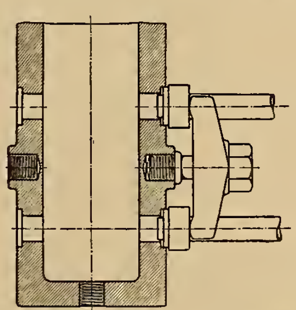


FIG. 7.—DETAIL OF SCHMIDT SUPERHEATER

Lowenburg, fitted with a Schmidt superheater, may be of interest. The *Lowenburg* belongs to the Hansa Line and was built in 1907 by Messrs. Swan, Hunter & Wigham Richardson. She has a length of 398 feet and a breadth of 54 feet. The registered tonnage is 4,657, the gross tonnage 4,444 and net tonnage 2,397. The ship is provided with triple-expansion engines, the cylinders being respectively 26-inch, 42½-inch and 70-inch diameter by 48-inch stroke. The steam is generated in two single-ended boilers at a pressure of 180 pounds per square inch. The grate area is 121 square feet, the heating surface, excluding the superheater, is 5,356 square feet, and the superheater surface is about 2,000 square feet.

In the Watkinson uptake type of marine superheater, as constructed by Messrs. Mechan & Sons, Scotstoun, Glasgow, a pair of headers is provided, these two headers being horizontal and connected together by inverted U-tubes. The arrangement is shown in Figs. 10, 11, 12 and 13. The saturated steam is admitted to the header nearest the boiler, and the superheated steam withdrawn from the other header. The headers are cylindrical and contain no longitudinal bolted joints. Fig. 14 shows the method adopted of expanding the tubes, which method is also employed should it be necessary to re-expand or to plug a defective tube.

THE PROS AND CONS OF SUPERHEATING

The addition of superheating tubes adds little to the weight of a boiler even if the grate area and water-heating and steam-generating surface remain unchanged; but for equal engine power the boiler weights (excluding the superheaters) should be reduced by the adoption of superheating, because both the grate area and the heating surface (excluding superheater surface) can be reduced, owing to the reduced steam consumption of the engines.

Superheaters have in many cases been added to vessels which have been in service using saturated steam, and the original boilers have been maintained unaltered except for the addition of the superheaters; and in some instances, where the chief reason, or one reason, for adopting superheating was on account of deficiency in the boiler capacity, the original grate area and heating surface have been found to be about right for use with the superheaters. In the case of boats originally designed for superheated steam, there is no unanimity of opinion as to the permissible reduction in boiler grate area and heating surface due to the provision of superheaters; and in some quarters there is an inclination to effect no reduction at all, so that with the superheaters out of use an ample supply of steam could be given to the engines, the superheaters being considered as an auxiliary equipment which should not be relied upon. In the writer's opinion superheating should not be so treated. Superheaters should be installed only if they are going to be considered as an integral part of the propelling machinery; and the boilers and engines should be designed and proportioned for the degree of superheat at which it is intended to work. Only by this means can the full advantage of employing superheated steam be obtained. The writer would suggest that in designing marine boilers for use in conjunction with superheaters, the grate area and the heating surface (excluding superheater surface) should, as far as can conveniently be arranged, be made smaller than would be provided in the case of saturated steam by a percentage which, in the case of the grate area is one-half, and in the case of the heating surface is two-thirds of the percentage reduction in steam consumption indicated in Fig. 3.

It may therefore be accepted that the boiler-room weights will not be increased by the adoption of superheating.

As regards the engines, it appears that with due care the ordinary de-

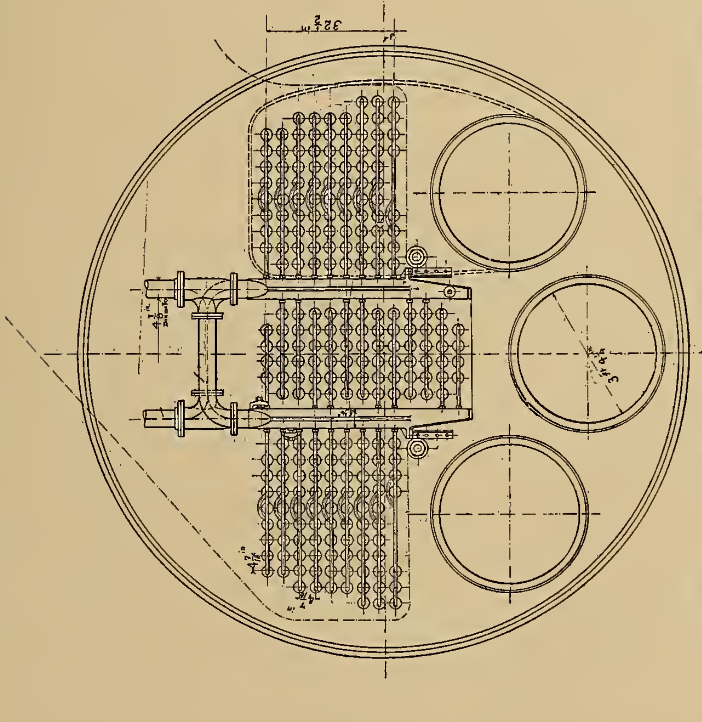


FIG. 8.—CROSS SECTION OF BOILER WITH SCHMIDT SMOKE-TUBE SUPERHEATER

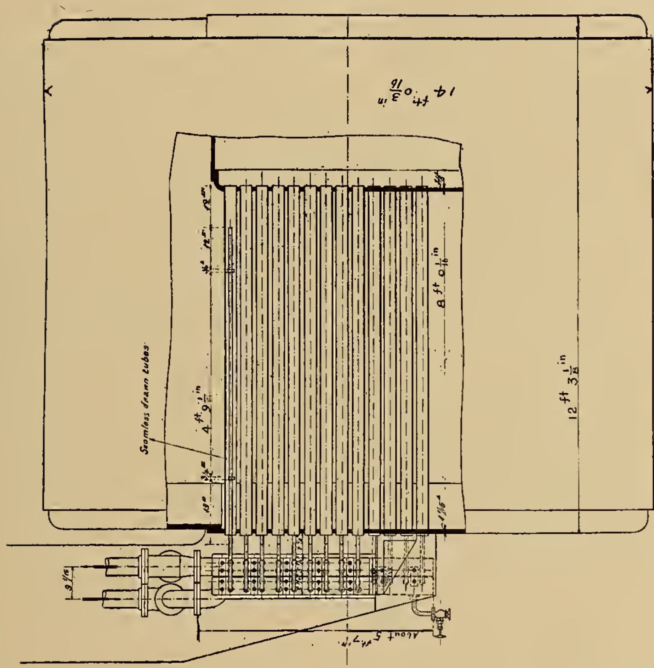


FIG. 9.—LONGITUDINAL SECTION OF BOILER WITH SCHMIDT SMOKE-TUBE SUPERHEATER

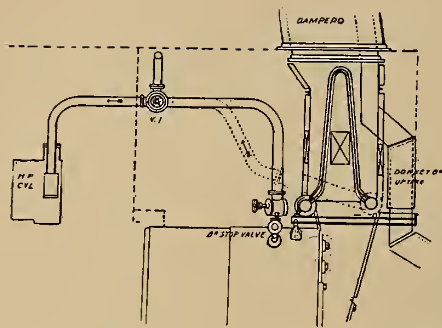


FIG. 10.—CONNECTIONS OF WATKINSON SUPERHEATER

sign of triple-expansion marine engine can be used with safety for moderate superheat—say 80 degrees Fahr., with steam generated at, say, 180 pounds per square inch absolute, above atmosphere. If, however, there is a likelihood of the steam temperature rising above 500 degrees Fahr., which corresponds to 120 degrees of superheat for steam generated at 180 pounds, the design of the engine requires careful consideration.

A large number of ship-propulsion engines are at the present day running successfully with steam supplied at temperatures above 500 de-

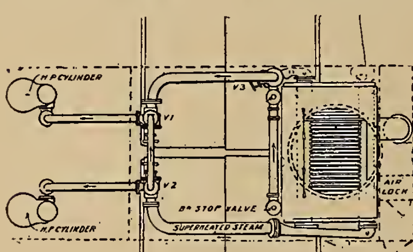


FIG. 11.—PLAN OF ARRANGEMENT OF WATKINSON SUPERHEATER

grees Fahr.—chiefly on lakes, rivers and canals on the Continent of Europe—and in many cases it is reported that no trouble has at any time been experienced. On the other hand, frequent cases have occurred where serious trouble has been met with—chiefly with regard to lubrication or lubricants. As, however, experience is gained and marine engineers become more familiar with the requirements of superheated steam, it is to be expected that troubles will become infrequent.

It is not only the lubrication of the sliding surfaces in the engines which requires careful attention, but also the removal of the lubricant before it can do harm. As the amount of lubricant required by the small engines in a vessel is proportionately greater than that required by the main engines, it would appear to be bad practice to exhaust engine-room auxiliaries, winches, or any other small steam plant, into the main condenser, or to allow the water of con-

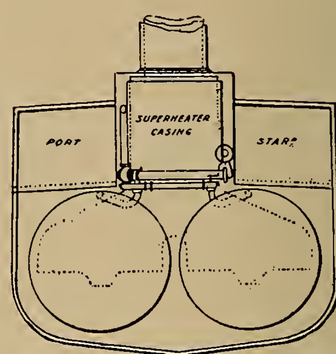


FIG. 12.—ARRANGEMENT OF WATKINSON SUPERHEATER WITH BOILERS

densation from these small engines to enter the main hot well, before removal of the oil has been effected. The proportion of oil in the main exhaust may be kept comparatively small in amount, and this oil can be removed by filters, of which efficient types are now obtainable. All the small engines can, with advantage, be exhausted into an auxiliary atmospheric condenser, and the water of condensation discharged into a separating tank in which the greater part of the oil can be separated out and discharged (with a certain amount of water), while the less oily water can then be filtered and used for boiler feed. It may also be advisable to employ an oil separator through which the steam is passed before being admitted to the auxiliary condenser. Messrs. Richardsons, West-

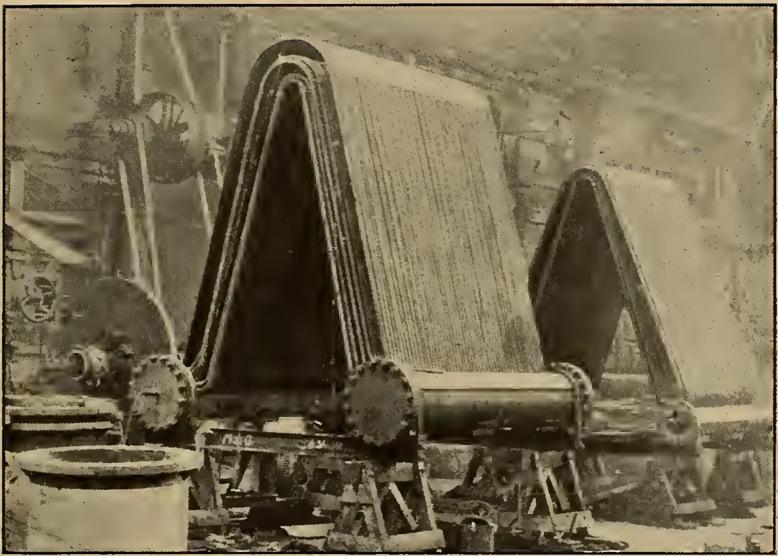


FIG. 13.—WATKINSON MARINE UPTAKE SUPERHEATERS IN COURSE OF CONSTRUCTION

ment of exhaust-steam oil separator, atmospheric winch condenser, and oil-separating tank for cargo steamships which would appear to be of special use in vessels in which superheated steam is used. The question of placing an oil separator in front of the main condenser also deserves consideration.

An important point in connection with superheated steam is that, by its use, high economy can be obtained without generating steam at very high pressures.

The engine-room weights should not be much affected by the adoption of either moderate or high superheat, so that the adoption of superheating should not add to the weight of the propelling machinery. The condensers will have a less weight of steam-plus-water to deal with; but the ratio of steam to water will be greater. Probably slightly smaller condensers will suffice with superheated than with saturated steam, but the saving will be trifling.

The chief effect of superheating on ship weights has reference to the bunker coal, the lesser coal consumption obtained with superheating allowing of less coal being taken on board for a voyage of given duration. For short voyages this saving in coal will of course be of little consequence as regards weight carried, but on long voyages it will be appreciable.

As regards initial cost of propelling machinery, the adoption of superheating will probably in all cases add to the initial cost. The installation of superheaters may be taken to add about £0.25 to £0.5 per indicated horse-power to the boiler room costs, which will hardly be balanced by the reduction which would be allowed on the size of the boilers; and engines designed for highly superheated steam may be expected to cost more than engines of similar power of the usual marine type. The difference in initial cost of propelling machinery is, however, not so great as to present a serious obstacle to the employment of superheaters; a reduction in coal consumption sufficient to be measurable in a sister ship would be more than enough to justify the difference in initial cost of machinery.

As regards depreciation, repairs and maintenance, a vessel employing superheated steam must compare un-

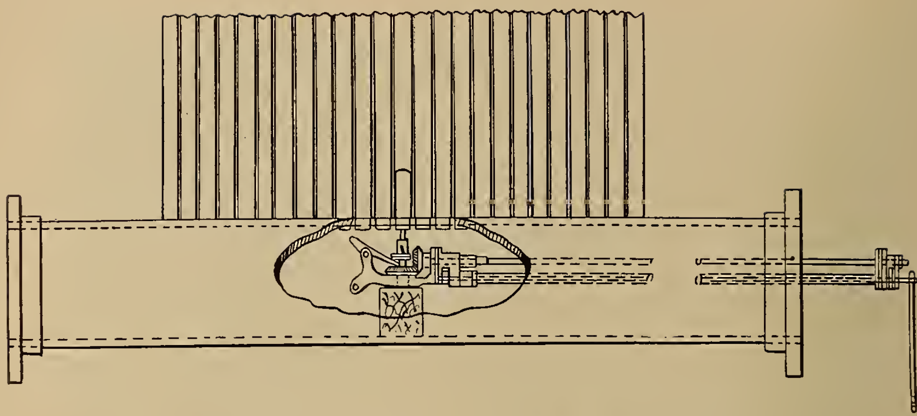


FIG. 14.—METHOD OF EXPANDING ENDS OF SUPERHEATER TUBES FROM END OF HEADER IN WATKINSON SUPERHEATER

favourably with one employing saturated steam, but in view of the moderate cost of upkeep of machinery in some vessels employing superheated steam and in view of the high quality of superheaters now obtainable, it would appear that it is not justified that considerations of depreciation, repairs and maintenance should be a serious argument against the adoption of superheating in the majority of cargo boats.

THE FAILINGS OF THE RECIPROCATING ENGINE

Reciprocating engines of the triple-expansion or quadruple-expansion type are complicated and, although very economical in the expansion of the steam down to moderate volumes, they cannot deal efficiently with very great specific volumes, such as correspond to low pressures of saturated steam. To expand to a low pressure in a piston engine would require a cylinder of such a size that, not only would the cost be excessive, but the extra weight to be carried would be objectionable, and the mechanical friction, initial condensation and valve leakage would all be increased, so that no greater economy in steam as regards brake-horse-power could be expected. As an example, it may be mentioned that at a pressure of one pound per square inch, absolute—which corresponds approximately to a vacuum of 28 inches of mercury with the barometer at 30 inches—one pound of saturated steam occupies 330 cubic feet. If steam at a pressure of 185 pounds per square inch by gauge were expanded to this vacuum in a cylinder without any loss of heat except that converted into work on the piston, then, allowing for condensation, the cylinder would require to be 90 inches in diameter by 70 inches stroke, or equivalent capacity, to contain a single pound of this steam. A quadruple-expansion engine to expand the steam to this vacuum and with such dimensions for its low-pressure cylinder might be expected to develop about 700 indicated horse-power at 80 revolutions per minute, but the brake-horse-power would be much less.

Steam turbines are simple and can make effective use of the heat energy in steam down to very low pressures. Moreover, they have a very fair efficiency over the whole range of pressure—say from 200 pounds per square inch, absolute, to one pound per square inch, absolute.

There are, however, well-known objections to the employment of steam turbines acting alone for the direct driving of the propellers of low-speed vessels, especially vessels of small or moderate size where the power required is not great. For

cargo boats, where the power of the engines is not more than 2,000 indicated horse power and the speed less than 11 knots, the direct-drive turbine is particularly unsuitable.

The unsuitability of the turbine lies in the fact that its desirable speed of rotation is far removed from the desirable speed of rotation of the propeller. To overcome this difficulty, three schemes have been proposed and to a certain extent tried, whereby the propeller can rotate at a lower speed than the turbine. These schemes respectively involve:

(1) Mechanical gearing.

(2) Electric transmission of power.

(3) Hydraulic transmission of power.

The mechanical gearing scheme, which at present looks the most promising of the three for cargo boat use, will be first considered.

TURBINES WITH MECHANICAL GEARING

At an early date in the history of ship propulsion by steam turbines, gearing was suggested; but not till recently has anyone had the courage and enterprise to try the employment of gearing on a large scale. During the last year, however, important experiments have been made by the Parsons Marine Steam Turbine Company, Ltd., and a mechanical speed-reducing gear has been tried—with what appear to be good results—on the steamship *Vespasian*, which was purchased by the Parsons Company for this purpose. Mr. George Westinghouse has also interested himself in the question and, in conjunction with Messrs. Melville & MacAlpine, has done much to prove the possibilities of transmitting high powers through helical gearing.

Gearing has already been successfully employed in De Laval turbines to reduce the extremely high rotary speed of the turbine wheel to a speed suitable for the driving of electric generators, or for the driving of machines by belts or ropes. The total power transmitted by the gearing of these De Laval turbines is, however, less than that required by most cargo boats, and the De Laval tooth pressures are low.

The *Vespasian*, which was built in 1887 by Messrs. Short Brothers, of Sunderland, has a length of 275 feet on the load water line, a moulded breadth of 38 feet 9 inches, a moulded depth of 21 feet 2 inches, a mean loaded draught of 19 feet 8 inches and a displacement of 4,350 tons. The vessel was originally provided with triple-expansion reciprocating engines by Mr. G. Clark, of Sunderland, and was run by the Parsons Company with these engines in order to get comparative data. The engines were then removed and in their place was installed a turbine-mechanical-gearing system. The vessel has since been tried with this new machinery and, while sufficient tests have not yet been made with the latter to enable it to be said what is the exact difference in coal consumption, there is no doubt that an improvement as regards the coal consumption has been effected. Moreover, as far as tests have already been made, both the turbine and the gearing appear to have worked very satisfactorily, independent engineers who have seen the machinery working having expressed themselves as well pleased.

As regards the comparative space occupied by the two types of machinery, this is best seen by comparing Figs. 15, 16 and 17, which show the original reciprocating machinery, with Figs. 18, 19 and 20, which show the geared turbines. The reciprocating engines had cylinders 22¼ inches, 35 inches and 59 inches in diameter by 42-inch stroke. The turbine machinery comprises a high-pressure and a low-pressure turbine arranged with parallel axis. The high-pressure turbine has a maximum diameter of 3 feet and an overall length of 13 feet. The low-pressure turbine has a diameter of 3 feet 10

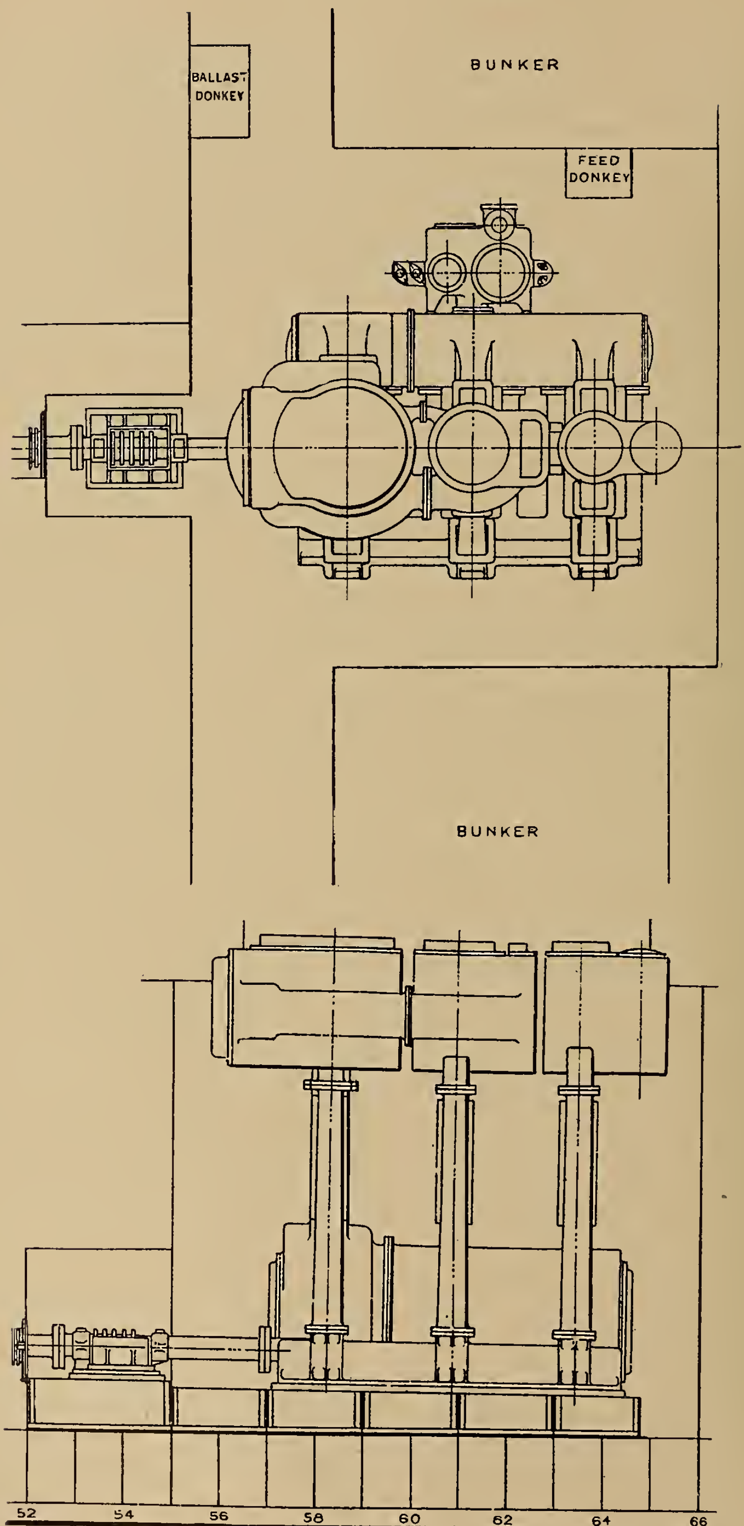


FIG. 15 AND 16.—GENERAL ARRANGEMENT OF ENGINES OF THE VESPASIAN

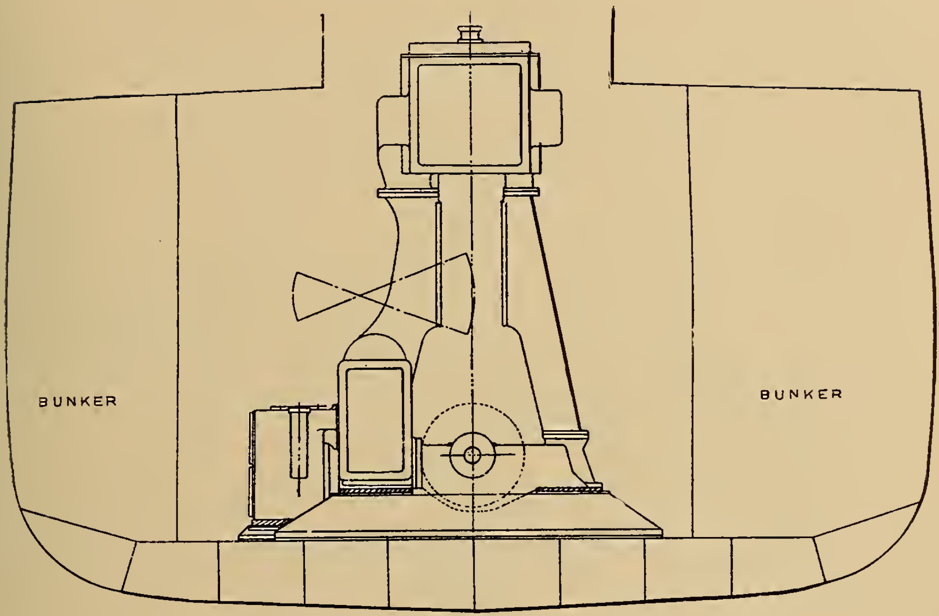


FIG. 17.—CROSS SECTION OF VESPASIAN, SHOWING RECIPROCATING ENGINES

inches and a length of 12 feet 6 inches.

The gearing is arranged aft of the turbines. Each turbine spindle carries a pinion, and both pinions gear into a common wheel which is secured on the propeller shaft. Each pinion is of chrome nickel steel, is 5 inches in diameter and has 20 teeth. The wheel is of cast iron, with two forged-steel rims shrunk on. It is 8 feet 3½ inches in diameter and has 398 teeth. In both wheel and pinions the pitch is 0.7854 inch. The face breadth is 24 inches and the teeth are double helical, with an inclination of 20 degrees to the tangential line parallel to the axis. The reduction ratio of the gearing is very nearly 20 to 1.

For 10½ knots the turbines rotate at about 1,420 revolutions per minute and develop about 1,000 horsepower, driving the propeller shaft at about 71 revolutions per minute. The turbines are more of the nature of machines employed for driving electric generators than of the usual ship-propulsion type. The propeller thrust is taken up, not by the turbines, but by the ordinary propeller shaft thrust block.

The boilers, propeller and propeller shaft which were originally used with the reciprocating engines have been retained for use with the turbines. The boilers, two in number, of the return-fire-tube type, have a total heating surface of 3,430 square feet and a total grate area of 98 square feet. The working pressure is 150 pounds per square inch. The propeller is of cast iron and has four blades. It has a diameter of 14 feet, a pitch of 16.35 feet and an expanded area of 70 square feet. The original condenser was cast with the back cylinders of the main engine and was removed with the engine. For use with the turbines a new condenser

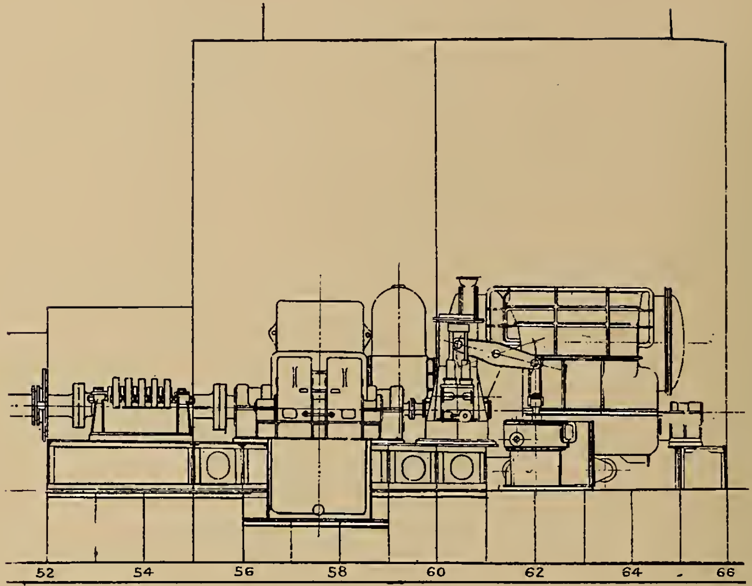


FIG. 18.—LONGITUDINAL VIEW OF TURBINE ENGINES AND GEARING ON THE VESPASIAN

was installed, which is provided with a Parsons vacuum augmentor.*

In gearing designed by Messrs. Melville and MacAlpine for Mr. George Westinghouse and designed to transmit 6,000 horse-power, a single pinion was employed. This pinion was of 14 inches diameter and had 35 teeth. The wheel was of 70 inches diameter and had 176 teeth. The pitch was 1¼ inches and the total face breadth 44 inches. The teeth were of the involute type. The pinion was designed to rotate at 1,500 and the wheel at 300 revolutions per minute. Tests carried out with this gear were reported to be satisfactory and the efficiency to have been high, and the United States Navy Department has decided on transmission gears of this nature in conjunction with Westinghouse turbines for the navy collier No. 8. This vessel will have twin screws driven through gearing by independent turbines. There will be only two turbine casings in all, each casing containing an ahead turbine capable of undertaking the complete expansion of the steam and also an astern turbine. Both ahead and astern turbines will be of the mixed impulse and reaction type. The total ahead horse-power will be 7,200.

It appears from the tests carried out on the *Vespasian,* tests by Messrs. Melville and MacAlpine, and tests on De Laval and other helical gearing, that accurately-cut double-helical gearing suitable for use on cargo boats could be, when new, run with frictional losses amounting to not more than 3 per cent. including the friction in the bearings. Sufficient experience has not yet been obtained with double helical gearing transmitting great powers at high speeds to enable it to be determined whether the efficiency will be much reduced in service.

In order to be able to form an opinion on the questions of desirable speed of rotation, system of gearing and dimensions, pitch, etc., of gear wheels, it is necessary to consider the

* Most of the above information about the *Vespasian* has been taken from the paper read by the Hon. C. A. Parsons, before the Institution of Naval Architects, on March 18, of this year, on "The Application of the Marine Steam Turbine and Mechanical Gearing to Merchant Ships." Figs. 11 to 16 have been reproduced from this paper by kind permission of the Institution.

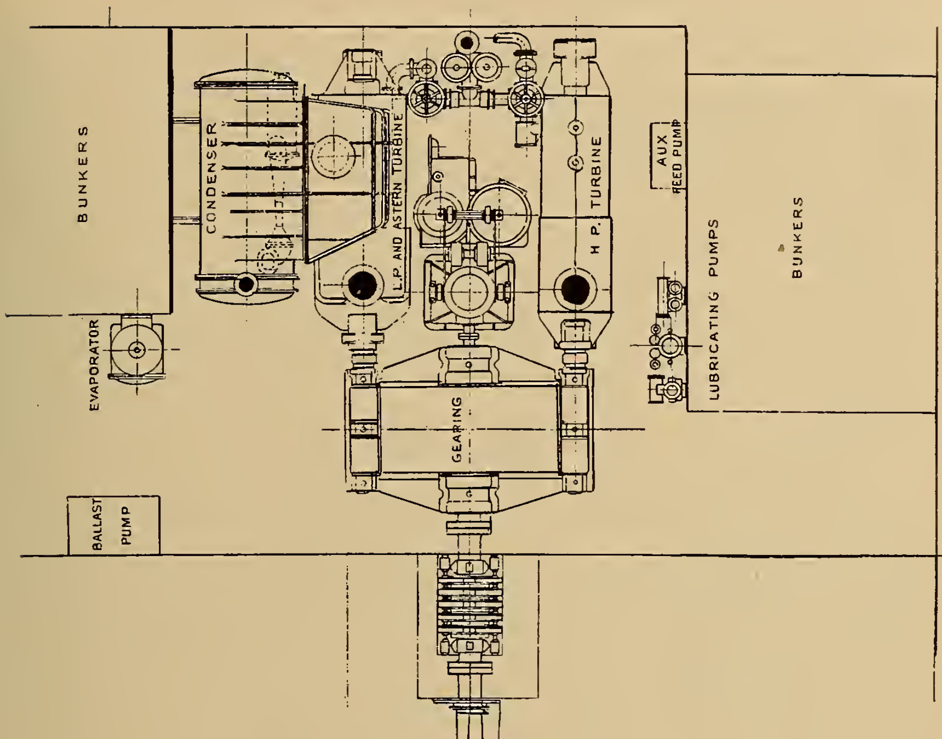


FIG. 19.—PLAN OF TURBINE ENGINES AND GEARING ON THE VESPASIAN

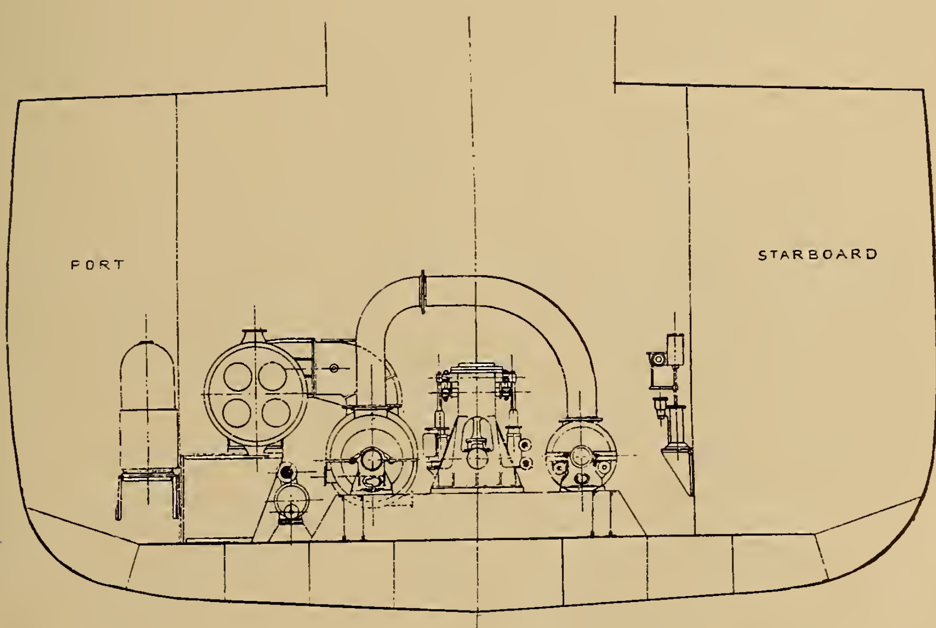


FIG. 20.—CROSS SECTION OF VESPASIAN WITH TURBINE ENGINES

velocities of and intensities of pressure on the teeth.

Let P = total pressure in pounds exerted by the teeth of the pinion on the teeth of the wheel in a direction perpendicular to the plane containing

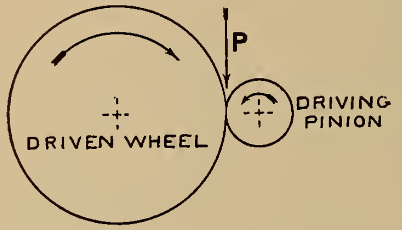


FIG. 21.—ARRANGEMENT OF TURBINE GEARING

the axes of wheel and pinion. (See Fig. 21.)

Let V = linear velocity of the teeth in feet per second measured at the pitch line.

Let $H.\ P.$ = horse-power transmitted by the gearing.

Then $H.\ P.$ =

$$\frac{P \times V \times 60}{33{,}000} = \frac{P\,V}{550} \qquad (1)$$

Let L = face breadth of the wheel and pinion (measured parallel to their axes) in *inches*.

$$\text{Let } p = \frac{P}{L}$$

$$\text{Then } H.\ P. = \frac{p\,L\,V}{550} \qquad (2)$$

p is to a certain extent a measure of the intensity of pressure on the teeth, whether the teeth are arranged parallel to the axes or in helices; but the intensity of pressure depends on the number of teeth in contact at one time on any right cross section of the wheel and also depends on the obliquity of the teeth.

It will be obvious from equation (1) that, if the horse-power is small, p, L, and V can all have low values, and the design of suitable gearing will be a simple matter if the radial dimensions of the wheels are not limited. For the transmission of large powers, however, either p or L or V, or two or all of these quantities, must be large. In De Laval turbines V has commonly been given a value of about 100 feet per second; and L has been given a high value compared with the diameter of the pinion (e. g., for a 5-horse-power turbine L is about 3 inches and the diameter is only about 11/16 inch), so that p has a very low value.

In the *Vespasian*, when the turbines are together developing 1,000 shaft horse-power, V is 31 feet per second. If each turbine develops half the total power then, as L is 24 inches, p is 370 pounds per inch. If one turbine develops greater power than the other, p will be somewhat greater than 370 in the one pinion and somewhat less in the other. One important advantage of employing two turbines on separate shafts is here seen, for, if one turbine only had been employed, or the two turbines arranged on the one shaft, p would have been doubled.

In the Melville-MacAlpine experimental gear above described, V is 91.6 feet per second and L is 44 inches, so that when 6,000 horse-power is being transmitted, p attains the very high value of 818 pounds per inch. This gear has not yet been tried on board ship, but it is of very great interest to learn that in the experiments that have been conducted on land, no trouble was experienced with such a high value of p, because it will not do to assume that with a Melville-MacAlpine gear as above referred to, but designed for a cargo boat of, say, 1,500 horse-power, the intensity of pressure on the teeth would be only a quarter of that given above for the 6,000-horse-power gear. This would be the case only if the tooth velocity and the face breadth of the wheel and pinion were kept constant. Now, with a cargo boat having a horse power of 1,500, it might be desired to rotate the propeller at, say, 75 revolutions a minute. In such a case, with the same size of wheel as above described, p would

still have the high value of 818, and this value could only be reduced by increasing either the diameter or the face breadth of the wheel.

With gear wheels with broad faces such as it will be necessary or advisable to employ in most cases, care will have to be taken to ensure that the pressure is distributed in a fairly even manner over the whole breadth of the face. The Hon. Charles A. Parsons, in the specification of a patent having reference to gearing, proposes devices whereby a certain amount of flexibility is allowed, so that the gear wheels can adjust themselves to distribute the pressure in an approximately even manner.* In the Melville-MacAlpine gear the same object is sought to be attained by supporting the double pinion in a "floating-frame" which is allowed to rock (the movement will of course be very slight) about a central support.

THE TURBO-ELECTRIC DRIVE

The second scheme, for enabling a high-speed turbine to be employed with a low propeller speed, consists in employing the turbine to drive an electric generator, which will supply current to a low-speed motor or motors on the propeller shaft or shafts. The high efficiency obtainable with turbo-generators working on land is well known; and it is hoped that by means of electric transmission of power greater economy of coal will be obtained than is at present customary in vessels driven by reciprocating engines, while it is contended that an economy in weight of machinery could also be effected. In the present investigation only cargo boats are being considered, and in such vessels there is little doubt that the total weight of machinery could be reduced by adopting the turbo-electric drive. A small advantage could also probably be obtained as regards coal consumption. The economy in weight would not, however, in a cargo boat be of very great moment. Comparing two boats, one with the ordinary recipro-drive and the other with the turbo-electric drive, it will only be necessary to enlarge the dimensions of the former and to increase the propulsive horsepower by a very small increment in order to allow of the same cargo being carried with the heavier machinery. The increase in the cost of the hull would be small, while the machinery of the turbo-electric vessel will greatly exceed in cost that of the other ship. The subject was discussed by the writer in a previous article in CASSIER'S MAGAZINE, in which it was shown that there was no prospect of financial success being attained by the adoption of the turbo-electric drive for cargo boats. The reader is referred to this article for further remarks on the merits and demerits of the scheme.* Since then the scheme has been further discussed before the Society of Naval Architects and Marine Engineers, New York; the Institution of Civil Engineers, London, and the Institution of Naval Architects, London, on the occasion of papers read before these institutions by Mr. W. L. R. Emmet,† Mr. H. A. Mavor‡ and Mr. W. P. Durtnall,§ respectively; but nothing has transpired to cause the writer to change his views.

STEAM TURBINES WITH HYDRAULIC POWER TRANSMISSION

The *Stettiner Maschinenbau-Aktien-Gesellschaft* and their chief engineer, Professor Föttinger, have recently attained considerable success with an hydraulic transmission gear whereby a high-speed steam turbine can be used in conjunction with a slowly-rotating propeller. The principle on which this scheme works is that the high-speed turbine drives a centrifugal pump which delivers

* British Patent No. 13,019 of 1906.

* "Turbo-Electric Propulsion for Vessels," by R. M. Neilson, *Cassier's Magazine*, Sept., 1909.

† Society of Naval Architects and Marine Engineers, New York, November, 1909.

‡ Institute of Civil Engineers, London, December 8, 1909.

§ Institute of Naval Architects, London, Spring Meeting, 1910.

water at a suitable velocity to a water turbine which drives the propeller. With a transmission gear of this nature efficiencies as high as 85 per cent. have been obtained. It may seem surprising that an efficiency as high as 85 per cent. should be obtainable, considering that 85 per cent. is a high efficiency either for a centrifugal pump or for a water turbine and that in the Föttinger gear the efficiency is the combined efficiency of the two elements. The explanation is found chiefly in the fact that the power has not to be transmitted any great distance. The two elements of the transmission gear, which can conveniently be designated the primary wheel and the secondary wheel respectively, are, in fact, built up together; and the water passes either directly from the one to the other or by way of a very short guide passage. It is therefore not necessary to convert the velocity energy of the water into pressure energy for transmission purposes. The high velocity given to the water in the primary wheel is retained till the water enters the secondary wheel. Eddy losses are therefore reduced to a minimum and, as the whole apparatus is very carefully and scientifically constructed, the high efficiency obtained is only what might be expected.

The 85 per cent. efficiency cannot, however, always be obtained: the efficiency depends upon the conditions of the case. For low reduction ratios, say, for example, when the propeller speed is half the steam turbine speed, a simple machine is employed, having only one secondary wheel. For greater ratios of reduction two or more secondary wheels have to be employed, through which the water passes in series, the efficiency thus being reduced. For reduction ratios of 4 to 6 two secondary wheels are recommended.

The Vulcan Company also claim a saving of energy to be obtained by passing the feed-water through the hydraulic gear, whereby the greater part of the frictional losses can be employed to heat the feed-water. A saving of energy by this means can, no doubt, be effected; but one must be careful not to over-estimate the advantages to be derived from such a scheme. About 10,000 British thermal units will have to be imparted to the water in the wheels in order to save one pound of coal; and this 10,000 British thermal units lost in friction will represent a waste of coal amounting to about 80,000 British thermal units. The waste of coal due to the frictional losses in the gear would of course be incurred whether or not the feed water were heated in the gear, and it is to be denied that this scheme of heating the feed water will increase the economy of the system; but it is as well to understand that this improvement in economy cannot be expected to be great.

With this Föttinger hydraulic gear, reversing of the vessel can be effected in several ways. One method consists in employing separate hydraulic gear for ahead and astern motion, while another method consists in employing certain parts of both primary and secondary wheels for both motions, and effecting reversal by re-arranging the water passages. There is also more than one way of regulating the speed of the vessel; but the simplest method consists in reducing the speed and power of the steam turbine by controlling the steam supply.

This Föttinger gear has been tried on a small vessel and is said to have worked satisfactorily. The gear has certainly possibilities of useful application in the future; but its efficiency, at the best, compares unfavorably with that of mechanical gearing. More particulars as to the working of the gear in service will be awaited with interest.

HYDRAULIC-JET PROPULSION.

Another possible scheme of propulsion for cargo boats is by means of water jets. This old idea was much discussed at one time and was tried on at least two British and two for-

eign warships between 1865 and 1882. It has in recent years been adopted in life boats not so much on account of efficiency but to avoid the use of a propeller which might get entangled.

Jet propulsion has, however, something in its favor at the present day which it had not in the past. High-speed steam turbines can now be employed to drive the pumps or water turbine in place of the reciprocating engines used in the past and the high over-all efficiency that can now be obtained with centrifugal pumps coupled direct to steam turbines, and the lightness, simplicity and moderate cost of these turbo-pumps, constitute factors of considerable importance in cargo boats. Moreover, improvements have recently been made in the method of discharging the jets so that in considering the subject of jet propulsion one must not be too much influenced by failure in the past but must consider the subject in the light of present-day attainments. Last year the German Society of Naval Architects discussed this scheme of propulsion and reference may be made to their transactions for opinions on its prospects. The turbine and pump could be run in the same direction for driving the vessel both ahead and astern; and reversing would be effected by altering the direction of the water discharge.

Comparing two cargo boats, one equipped with a turbine-jet propelling arrangement and the other with reciprocating engines and screw propeller, it may safely be assumed that the turbine of the former would have a considerably higher efficiency than the reciprocating engines of the latter; but, on the other hand, the combined efficiency of pump and jet in the former would probably be considerably less than the combined efficiency of shafting and propeller in the latter. Even with a slightly greater coal consumption per propulsive horse power, the turbine-jet machinery might still justify its employment on account of its reduced weight, bulk and initial cost, its greater simplicity, and its reduced cost of upkeep; but any great increase in coal consumption per propulsive horse power, say above 10 per cent, would certainly prevent its adoption unless perhaps in certain exceptional cases.

SUPERHEATED STEAM FOR HIGH-SPEED TUBRINES.

The four schemes just considered —viz., steam turbines with mechanical gearing, steam turbines with electric transmission of power, steam turbines with hydraulic transmission of power, and steam turbines with water turbines—all involve the employment of high-speed steam turbines which would be very much of the nature of the machines at present employed on land for the driving of electric generators. It may be said to be now the standard practice in turbine power stations on land in all parts of the world to superheat the steam before supplying it to the turbines. The decrease in steam consumption so obtained is so great as distinctly to overweigh the disadvantages and risks attendant on the production and use of the superheated steam. The tendency at the present day is to employ a superheat of at least 150° Fahr.; and anything between 100° Fahr. and 200° Fahr. may be considered as in accordance with common practice.

Fig. 22* gives the results of a number of independent tests made in Great Britain, on the Continent of Europe, and in America, on condensing turbines of different types. In all cases the turbine was running at not less than half load, and the terminal pressure was never greater than three pounds per square inch. It will be seen that a superheat of 150° Fahr. reduces the steam consumption about 15 per cent., while a reduction of about 19 per cent. is to be expected from a superheat of 200°.

* This figure has been taken from the fourth edition of the writer's book "The Steam Turbine (Longmans & Co.), but the results of three recent tests have been added.

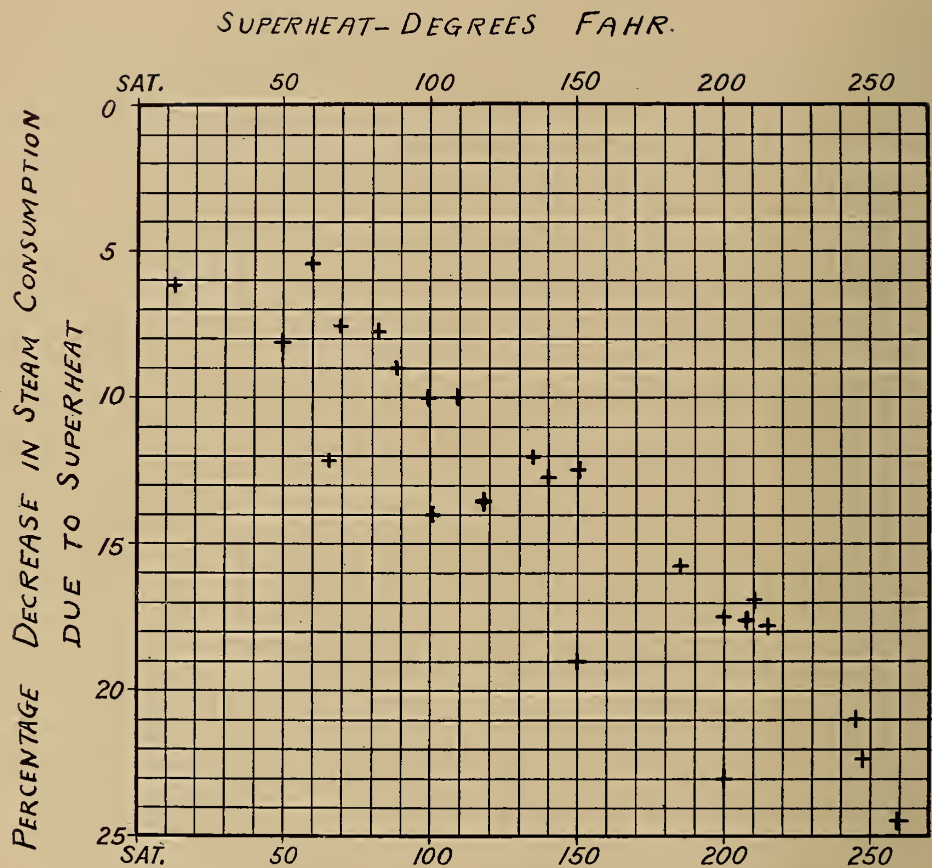


FIG. 22.—INFLUENCE OF SUPERHEATING ON STEAM CONSUMPTION OF TURBINES. VARIOUS INDEPENDENT TESTS

The reduction in coal consumption depends on the efficiency of the boiler and superheater. It is of little use to take figures on boiler efficiency from land practice; but it may safely be assumed that in a cargo boat the efficiency of a boiler provided with a superheater should be no less than that of a boiler without a superheater. Now from feed water, say, at 90° Fahr., it takes 1108 British thermal units to generate steam at a pressure of, say, 180 pounds above atmosphere, and it takes about 87 British thermal units to superheat this steam 150° Fahr., and about 114 British thermal units to superheat it 200.° The superheating of the steam 150° and 200° therefore involves an increase in heat absorption of 7.9 per cent. and 10.3 per cent., respectively, so that the reduction in coal consumption for 150° superheat may be taken as $100(1—0.85 \times 1.079) = 8.3$ per cent. and for 200 superheat as $100 (1—0.81 \times 1.103) = 10.6$ per cent.

The objection to superheated steam may be greater in a cargo boat than in a power station on land, but not sufficiently great, in the writer's opinion, to justify the denying of the substantial reduction in coal consumption obtainable by its use. There is no difficulty in constructing turbines to stand a temperature of 600° Fahr., and, as said in a previous part of this article, reliable superheaters are now obtainable which should not cause much trouble in service. There is certainly a risk of damage to the

turbine through unequal expansion, which risk is of course greater with superheated than with saturated steam. It is found, however, from experience gained on land, that this risk is very small when due precautions are taken.

In the scheme with mechanical gearing, however, it will probably be found better for going astern to reverse the turbines (or one turbine), as is done in the *Vespasian,* rather than to reverse the direction of rotation by gearing and clutches. The sudden admission of superheated steam to the astern turbine will in such a case be inadvisable; and to employ superheated steam in a vessel so arranged without providing means whereby reversal can be effected at a moment's notice without the admission of high-temperature steam to a cold reversing turbines is a course not to be recommended. To obviate the difficulty it has been proposed to keep the reversing turbine constantly heated by live steam, but there would appear to be other solutions of the problem.

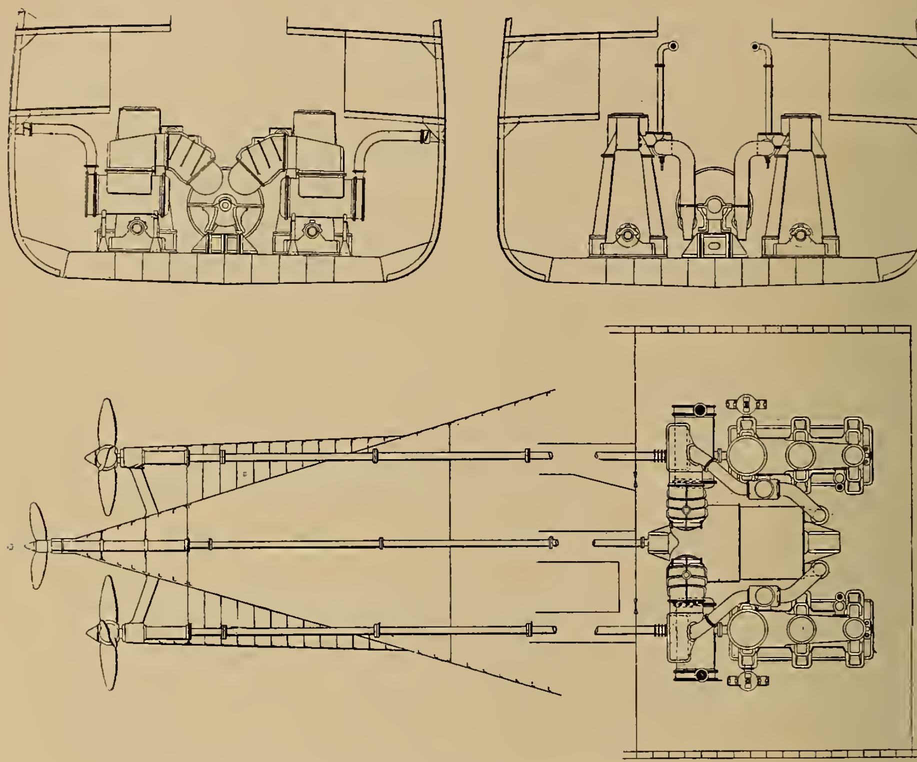
A patented heat buffer which Messrs. C. A. Parsons & Co. are introducing for use on land might, with advantage, with suitable modifications, be employed at sea, and would be specially advantageous in vessels where a reversing turbine or turbines are installed. The heat buffer is intended to prevent high-temperature steam being suddenly admitted to a relatively cold turbine and to prevent violent fluctuations in the temperature of the steam at admission to the turbine. As designed for use on land the buffer consists of a vessel through which superheated steam coming from the boiler room is passed before admission to the turbine. The body of the buffer is made of steel plates with iron or steel flanges. The top and bottom of the buffer are of ribbed cast steel, with branches arranged to suit the pipe connections. Soft iron bars are supported on a cast steel grid fitted in the bottom of the buffer and serve to absorb the excess of heat when steam at a high temperature is suddenly admitted to the vessel or when a current of steam flowing through the vessel to the turbine undergoes a sudden rise in temperature. The buffer will also be of service when a sudden fall of temperature occurs and, moreover, acts as a separator, a cock being provided in the bottom of the vessel for draining off any accumulation of water.

THE RECIPRO-TURBINE COMBINATION.

The employment of low-pressure turbines to utilize the steam exhausted from high-pressure reciprocating engines is now common practice on land; and the combination arrangement as applied to ship propulsion has been much discussed and has already been adopted on a few vessels.

With reference to the bearing of the subject on cargo-boat propulsion, the vessels of most interest which have been fitted with combination machinery are the New Zealand Shipping Company's boat the *Otaki,* built by Messrs. Wm. Denny & Bros., and engined by Messrs. Denny & Co., and the White Star steamship the *Laurentic,* built and engined by Messrs. Harland & Wolff. In both vessels three shafts are employed, a set of reciprocating engines driving each wing shaft and a low pressure-turbine, which normally receives steam from both reciprocating engines, driving the centre shaft. Moreover, in both vessels the reciprocating engines are of the triple-expansion type and two condensers are provided. The steam exhausting from the turbine is normally divided between the two condensers, but, when occasion arises, the turbine can be cut out and the steam exhaust from the reciprocating engines direct to the condensers, one condenser serving for each set of engines. This arrangement is adopted when going astern, the turbine shaft not being arranged to reverse.

The engine-room arrangement in-



FIGS. 23, 24 AND 25.—ARRANGEMENT OF MACHINERY ON THE OTAKI

the *Otaki* is shown in Figs. 23, 24 and 25. The condensers are placed directly aft of the piston engines and in line with these, while the turbine is placed with its exhaust end directly between the two condensers and its admission end between the two sets of piston engines. The turbine does not, however, extend so far forward as the piston engines. This arrangement is compact and convenient. In the *Laurentic* the arrangement is generally the same, but the turbine is situated further aft.

This design and arrangement of machinery is not, however, the only possible one for cargo boats. The piston engines might be of either the double-expansion or the quadruple-expansion type—both have been proposed—and one set of piston engines driving a central shaft might be used in conjunction with two turbines each driving a wing shaft. Twin screws have also been proposed, one driven by a set of piston engines and the other by a turbine; and this arrangement appears quite feasible; the shafts need not be at equal distances from the centre line of the ship. The vessel would not, of course, have all the advantages of a twin-screw boat.

In the *Otaki* the engine room was no larger than that in the sister ship the *Orari*, but the length of the *Otaki* was made 4 feet 6 inches greater than that of the *Orari*, to make up for the loss in cargo capacity due to there being three shaft tunnels instead of two. In many cases, however, the engine room would have to be of greater size for combination machinery than for the ordinary reciprocating drive. The total weight of machinery in the *Otaki* is about 30 tons greater than that in the *Orari*, the difference being about 3½ per cent. of the *Orari's* machinery

weights. The same boiler installation was, however, fitted in both vessels, whereas the *Otaki* requires considerably less steam for the same speed.

The number of expansions which it will be advisable to employ in the reciprocating engines depends on the steam admission pressure and on the pressure at which the steam is transferred to the turbine. If steam is generated at a very high presure, say 250 pounds per square inch by gauge, and is not superheated, and if the transfer pressure is comparatively low—say 7 to 9 pounds per square inch absolute—it will probably pay to adopt quadruple-expansion for the piston engines. The work obtainable from the steam expanding from 265 pounds absolute (i. e., 259 pounds by gauge) to 8 pounds absolute is somewhat more than double that obtainable by expansion from 8 pounds downwards, the exact ratio depending on the vacuum, so that to get a proper distribution of work between the shafts, two of these would require to be driven by reciprocating engines and one by a turbine. The arrangement would therefore be the same as in the *Otaki* or *Laurentic,* except that the reciprocating engines would be quadruple expansion. As the efficiency of reciprocating engines would be greater than that of the turbine, the centre shaft would transmit less power than either of the wing shafts, but as the centre propeller, owing to its greater speed of rotation, would be less efficient than the wing propellers, the division of work would be conducive to economy.

Such an arrangement would probably represent the highest efficiency that could be obtained in the propulsion of a cargo boat by steam power without employing superheated steam. The engine-room weights would be somewhat high, but the extremely low steam consumption that would be obtainable would allow of the cutting down of the aggregate heating surface and grate area of the boilers to values considerably below the usual. The total machinery weights would not be excessively high and would not be an objection to the adoption of this arrangement. What objection there is has reference rather to the high steam pressure—250 pounds.

While, as aforesaid, maximum efficiency would be obtained by such an arrangement with such a steam pressure (250 pounds) and superheated steam, it would be better to sacrifice a little efficiency and secure a reduction in weight and cost of engines by adopting a slightly higher transfer pressure and employing triple-expansion instead of quadruple-expansion engines.

If superheated steam were employed in a combination boat, and if this vessel were intended to run at a speed not less than 13 knots (and the best-paying speed may be higher by half a knot or so in a combination cargo boat than in one propelled in the usual way) a good arrangement of machinery would appear to involve one set of reciprocating engines driving a centre shaft, and two low-pressure turbines, each on a wing shaft. The reciprocating engine should in this case, in the writer's opinion, be double-expansion with three cranks, i. e., one high-pressure and two low-presure cylinders; and the transfer pressure should be high. The steam could advisedly be generated at about 180 pounds per square inch above atmosphere and transferred to the turbine at about five or ten pounds above atmosphere. The power transmitted by the centre shaft would then be, roughly speaking, about equal to the aggregate power transmitted by the two wing shafts; and the centre shaft alone need be reversed. The turbine shafts could with advantage be rotated at a higher speed with such an arrangement than were a single low-pressure turbine employed; and the whole engine-room machinery would be of small weight and low cost for the power.

It must not be thought, however, that this last-described arrangement

is the only one suitable for use with superheated steam, or even the most efficient. One would expect slightly greater efficiency with the *Otaki* arrangement, i. e., two sets of triple-expansion reciprocating engines and one low-presure turbine, with a transfer pressure of seven to eleven pounds absolute, and this arrangement would be suitable for use with superheated steam, not only for a steam pressure of 180 pounds above atmosphere, but for any higher steam pressure which might be desired. A steam pressure as high as 255 pounds above atmosphere has been fixed on for cargo boats employing superheated steam, but there appears to be less inducement to adopt such a high pressure with superheated than with saturated steam, as the maximum limit of superheat which it may be deemed advisable to adopt is determined by considerations of temperature; and hence the higher the steam pressure (and therefore temperature of steam generation) the less the permissible superheat.

Whatever arrangement of piston engines and turbines is adopted, and whether it is intended to employ superheated or saturated steam, it is necessary, in fixing the transfer pressure, to consider the speed at which the vessel will do most of her steaming and also to consider if much running will be done at lower or higher speeds. Moreover, as the vacuum obtainable with condensing plant of reasonable weight and cost is greatly influenced by the sea temperature, the work obtainable from the turbine will depend largely on the sea temperature. This is especially the case with low transfer pressures. If, for example, due to rise in the sea temperature, the vacuum falls from 28 to 27 inches (with barometer at 30 in.), and if the transfer pressure is only 7 pounds absolute and is maintained constant, the shaft horse power of the turbine may be expected to fall about 20 per cent. The route or routes on which the ship is intended to run should therefore, if known, be taken into account when fixing the transfer pressure.

The experience derived from the *Otaki* has conclusively proved—although there should never have been any doubt on the matter—that greater economy can be obtained with the recipro-turbine combination than can be got from reciprocating engines alone. In the case of the *Otaki* the increase in coal economy over her sister ship amounts to about 8 or 10 per cent. under service conditions. It may be said that the steam consumption of cargo boats with reciprocating engines varies much more than 10 per cent. This is undoubtedly the case; but when, as in the present case, the results of carefully considered tests on sister ships by the same builders agree in the main with the results obtained on service and are supported by scientific considerations, conclusions may safely be drawn. Further, it may be said that the *Orari's* machinery could be improved. It might, but the *Otaki's* machinery could also be improved; it would be unreasonable to expect that a first attempt could not be improved upon.

The recipro-turbine combination has also been proposed in conjunction with mechanical, electrical or hydraulic transmission of power from the turbine shaft to a low-speed propeller shaft, which may be either the shaft driven by a set of reciprocating engines or an independent shaft. Figs. 26 and 27 show an arrangement suggested by the Hon. C. A. Parsons in 1906. A set of reciprocating engines represented by *a* drives a propeller shaft *b* on which is mounted a chain wheel *r*. Two low-pressure turbines *e, e* receive, by way of the pipes *d, d,* the steam which exhausts from *a*. The turbines, which exhaust into condensers *c, c,* drive on to the propeller shaft *b* by means of chains *o, p, q*. In reversing the ship, the turbine is cut out and the reciprocating engines exhaust directly into the condensers *c, c* by way of the pipes *i, i*.

The writer does not himself think

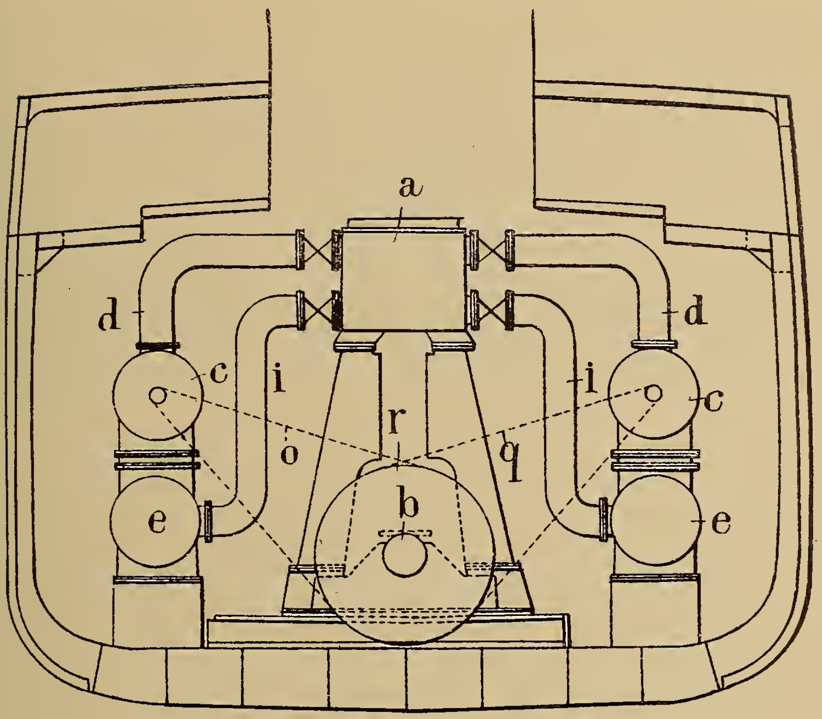


FIG. 26.—SECTION OF VESSEL, SHOWING ARRANGEMENT OF RECIPROCATING ENGINE AND TURBINE WITH SINGLE PROPELLER SHAFT

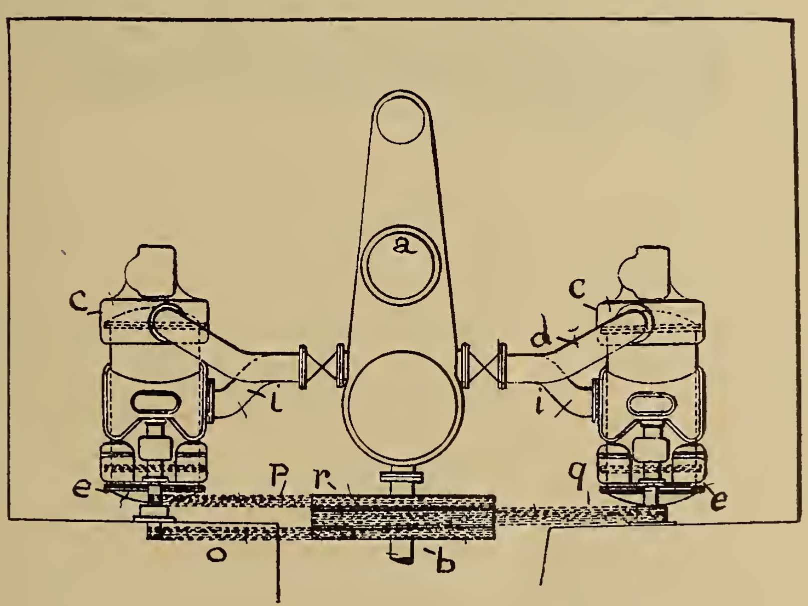
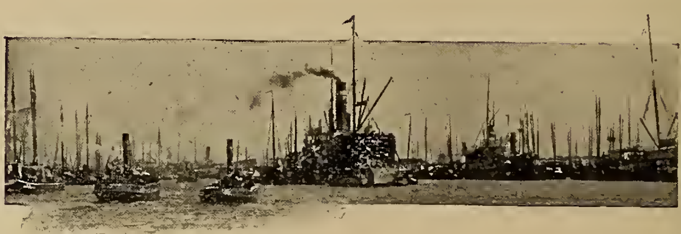


FIG. 27.—PLAN OF RECIPRO-TURBINE COMBINATION WITH SINGLE PROPELLER SHAFT

that with the recipro-turbine combination any indirect drive offers sufficient inducement to justify its adoption. If mechanical gearing is proved by experience to be satisfactory, turbines alone should be chosen for the propelling engines rather than a combination arrangement; while, as regards electric and hydraulic transmission of power, the losses would be so considerable that the increase in the efficiency of the turbine and propeller could hardly, except in very slow-speed boats, be expected to exceed the loss due to the double conversion, seeing that—and this is the important point—the avoidance of a direct drive involves a less gain in the case of a low-pressure than in the case of a high-pressure turbine. Even in cases where a very small net gain seems probable, which would not likely occur except in small vessels, this gain would generally not justify the extra complication and—in the case of electric transmission—the extra initial expense.



THE NEW HARBOUR WORKS AT CONSTANZA, ROUMANIA

By Fr. Bock

It is now fully recognized that the food supply of the world must depend largely upon the proper provision of transportation facilities, and the engineer has been called upon in many parts of the world to provide appliances for the mechanical handling of grain at terminals, so that trains and vessels may be subjected to a minimum amount of delay. The great grain fields of eastern and southern Europe find their outlet to the sea largely through the ports of the Black Sea, and hence the following account of the important improvements at the harbor of Constanza or Kustendje, through which much of the grain of Roumania is shipped abroad. The extent of these improvements is clearly shown in the following pages, and the illustrations indicate the substantial character of the buildings and works.—The Editor.

THE new harbour works, constructed after the plans of M. Saligny, the general manager of the Roumanian State Railways at the port of Constanza, on the Black Sea, by order of the Roumanian Government, were recently opened by the King of Roumania. The completion of this work gives Roumania a new and important terminal and port on the Black Sea, especially adapted for the export of the principal products of the country, grain and petroleum. The equipment of the harbour demands especial attention, as being wholly modern and complete.

The huge storehouses for grain are of the greatest interest, since they have a capacity of more than 150,000,000 pounds (2,600,000 bushels), and with the exception of the old Roumanian Government warehouse at Galatz and Braila, they are claimed to be the largest on the Continent.

An examination of the extensive arrangements for receiving, weighing, storing, and shipping the grain will give an idea of the tremendous quantity which is brought from the interior of the country. It has been only by installing the latest types of machinery, operated by electric power, that it has been found possible to transfer, simultaneously, 1,200,000 pounds of grain (200,000 bushels) from the railway cars into the storehouses, 600,000 pounds (100,000 bushels) directly into a vessel, and another 1,200,000 pounds (200,000 bushels) from a steamer into a warehouse in a single hour, as is now done at Constanza.

The mechanical equipment of the new harbour works and all the shipping arrangements are due to Messrs. Luther & Co., of Brunswick, Germany, who were also the builders of the equipment and floating grain elevators for the storehouses at Galatz and Braila.

The harbour of Constanza is protected against the violence of the sea by three breakwaters, of which the Wide Dam, extending in a north and south direction for a length of 1,377 metres, opposes the waves which come from the north and east; the South Dam, 1,496.77 metres in length, extends from east to west; while the Canal Dam projects at right-angles to the Wide Dam for a length of 119.28 metres. The mouth of the harbour, 160.70 metres in width, is between the South Dam and the Canal Dam, and the extreme ends of the breakwaters are provided with lighthouses to permit the safe entrance of vessels during the night.

The Wide Dam, situated at a distance of 400 metres from the mouth of the harbour, protects the outer harbour, providing a safe place for vessels while steering for the inner harbour.

The quays, as well as the break-

THE HARBOR FRONT AT CONSTANZA

waters, are built upon foundations of concrete blocks, laid in beds dredged in the bottom, this construction extending up to the water level, above which masonry of stone laid in cement is used. A passageway for the electric mains and other connections is constructed in this masonry, while the water front of the quays is equipped with fastenings for vessels, and with steps to permit access to barges.

The water area enclosed in the inner harbour is 60 hectares (148 acres), and in the outer harbour 14 hectares (about 35 acres), divided into several basins, as follows:

1. The basin at the Wide Dam in front of the quay;

2. The basin of the old harbour,

GENERAL VIEW OF WAREHOUSES AND TRACKS AT THE PORT OF CONSTANZA

THE CONVEYOR STRUCTURE ALONG THE QUAYS AT THE HARBOUR OF CONSTANZA

bounded by the Dam, the quay for piece goods and the North quay;

3. The grain basin, bounded by the North quay, the Mattamore quay and the northern part of the grain dam;

4. The basin for timber is bounded by the southern quay of the grain dam, the quay of the repair docks, and the northern quay of the timber dam;

5. The basin for coal, which is bounded by the southern quay of the timber dam, and the coal quay; and

6. The basin for the petroleum shipments.

The depth of the water at mean level is 8.25 metres in all the basins, except the petroleum basin, in which the depth is 9.25 metres, owing to the greater draught of the tank steamers.

The port itself, comprising an area of about 108 hectares (267 acres) between the shore and the quays, is equipped with ample rail-

VIEW ALONG THE QUAY DURING THE CONSTRUCTION OF THE BELT CONVEYOR HOUSING

way tracks, connecting all the quays, the passenger station, the wharves for the vessels of the Roumanian Navy, and the grain warehouses, etc. Since the export of products from the port of Constanza far exceeds the imports, especial attention has been given to the facilities for the rapid and convenient handling of the special products which constitute the exports, these being grain, petroleum, and timber, which three materials form 85 per cent. of the total trade of the harbour.

The installation for handling the grain trade at Constanza include two storehouses, each having a storage capacity of 35,000 tons (about 1,300,000 bushels), or 70,000 tons (2,600,000 bushels) in all. There is also a mechanical equipment for delivering grain directly from the railway cars into the vessels, without passing through the warehouses at all. The warehouses are connected with an overhead structure running along the edge of the quays, a length of 570 metres (1,870 feet), this containing conveying belts, delivering the grain into movable hoppers and chutes for loading directly into vessels. This delivery system is capable of handling grain from the warehouses, or directly from the trains in which it arrives. The length of the quays, 570 metres, permits the loading of five vessels simultaneously, and it is intended to have the apparatus extend to serve ten ships, the vessels being placed in two rows in this latter case.

Each warehouse covers a ground area of about 3,000 square metres (32,292 square feet), with a height from foundation to the top of elevator towers of 51 metres (167 feet); the vertical movement of the grain being effected by elevators, and the horizontal travel by conveying belts.

The equipment permits of the following operations:

1. The storage of grain arriving by railway;

2. Reloading of stored grain into vessels;

3. Cleaning, ventilation, mixing, and transportation of grain from one bin to another.

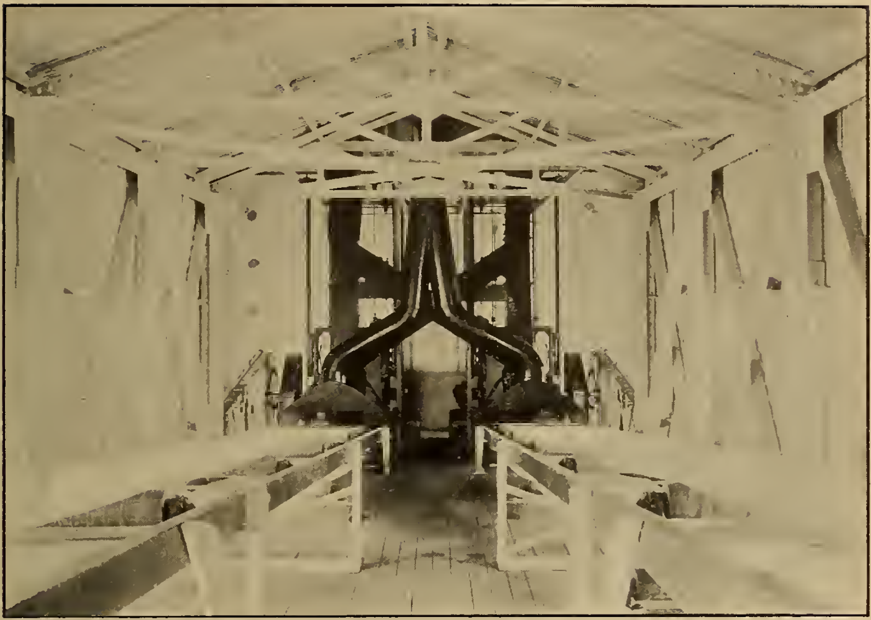
In addition to the handling of grain, the next most important article exported from the port of Constanza is petroleum. The installation for handling this commodity and for the storage tanks is situated on the

THE NEW DOCKS AND WAREHOUSES AT CONSTANZA, ROUMANIA, ON THE BLACK SEA NEAR THE MOUTH OF THE DANUBE

TRAVELING CHUTES FOR DELIVERING GRAIN TO VESSELS

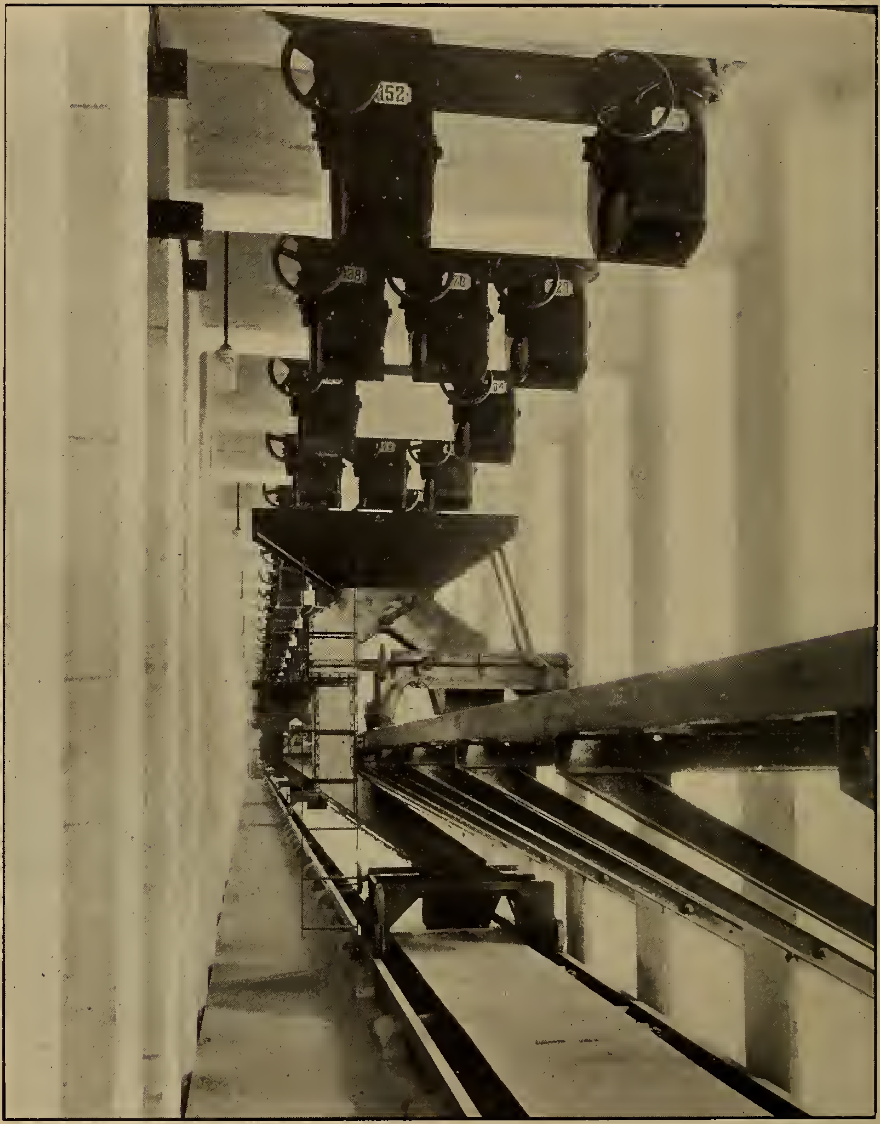
western side of the harbour, both on shore and in connection with the petroleum basin. These include facilities for receiving the trains and unloading the petroleum and its derivatives, together with tanks for storage and apparatus for reloading.

The station for the arriving trains is situated on the shore at a point having an elevation of about 33.5 metres (110 feet); there being six tracks of 350 metres (1,148) in length each. Four mains are arranged between these tracks, with connections to flexible tubes at every three metres, enabling every car in a train to be connected with any one of the mains. Each of the four mains is used for a single product, either benzine, refined petroleum, distilled petroleum, or residues, each main being connected to a receiving tank of 700 cubic metres capacity (24,720 cubic feet), into which the material is discharged by gravity. There are twenty-five storage tanks, each 22 metres in diameter, and 13.40 metres high, having a capacity each of about 5,000 cubic metres (176,570 cubic feet); connection from the receiving tanks to the storage reservoirs being made by pipes, 200 millimetres in diameter (7.874 inches). These connecting pipes are carried on an independent metallic structure high above the tanks, and there are branch connections enabling the material to be delivered into any desired tank. Four special storage tanks are provided for the residues, this



AN INTERIOR VIEW IN THE CONVEYOR HOUSING ON THE QUAY

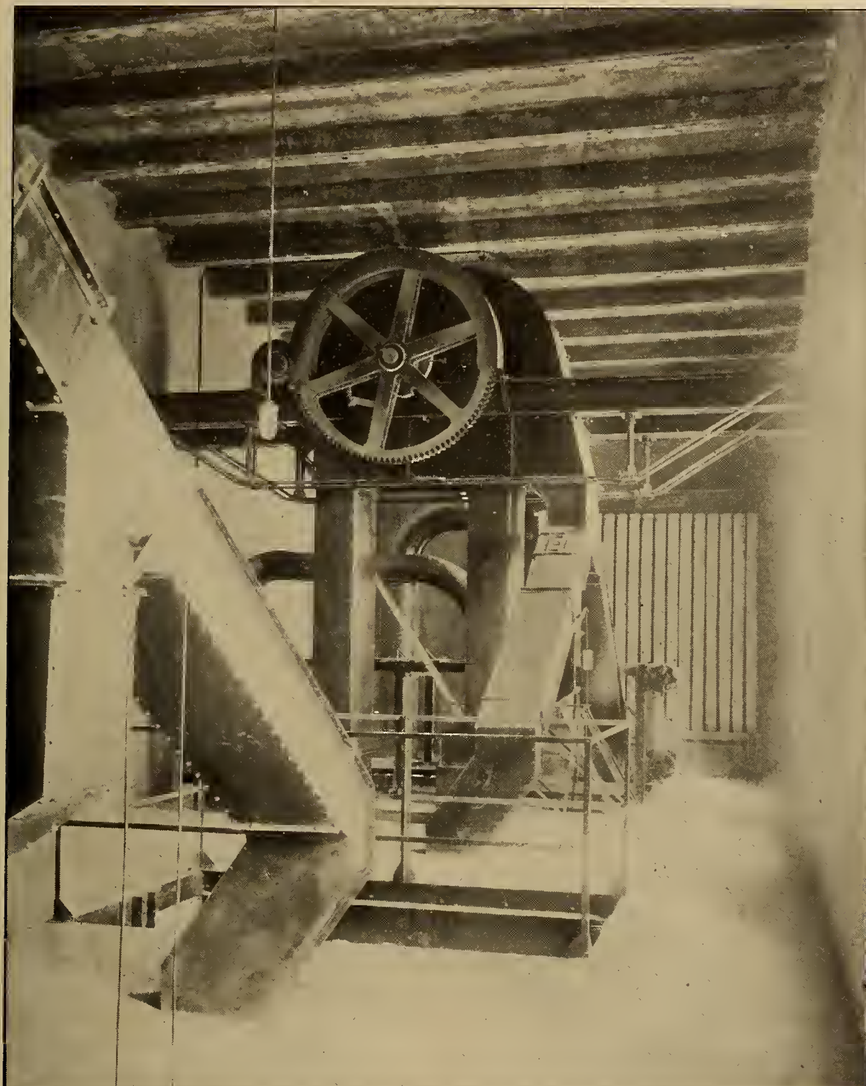
ARRANGEMENT OF DELIVERY CHUTES FROM BELT CONVEYOR TO GRAIN BINS



CONVEYOR BELT AND CONNECTIONS BENEATH GRAIN BINS IN THE WAREHOUSES AT CONSTANZA

material being pumped through an underground main, 250 millimetres in diameter. All the storage tanks are provided with covers, containing 20 centimetres depth of water, to prevent evaporation by the heat of the sun.

The reloading of the oil is effected by pumps, these being of the double-acting plunger type. There are five such pumps; one for each of the special products, and an extra one for reserve. These pumps are placed about 3 metres above the dock level, and are driven by three gasoline motors, two of 30 horse-power, and one of 50 horse-power. A system of mains connecting with the tanks enables the oil to be drawn from any point and delivered into a pipe line, 1,100 metres in length, leading to the ships.



ELEVATOR HEADING RECEIVING GRAIN FROM THE BELT CONVEYOR FOR DELIVERY TO THE SHIPPING SCALES

In addition to the special equipment already described there is an electric power crane of 50 tons capacity, and a number of 2-ton cranes. Power for all purposes is generated in an electric power house, which also furnishes current for lighting the harbour and buildings of the port.

This power house contains four units, each consisting of a 400-horsepower Diesel motor, using crude oil as fuel, and driving a direct-current dynamo of 270 kilowatts, the current being delivered at 440 volts for power, and 220 volts for lighting, the distribution being on the three-wire system, with a storage battery for reserve.

ELECTRICITY ON SHIPBOARD

By J. M. Heslop

The following practical notes, forming an abstract of a lecture recently delivered before the Engineering Society of the Technical College of Sunderland, will be found to cover many points in an important special application of electricity, and cannot fail to be of interest to ship builders and owners.—THE EDITOR.

IT is now about thirty years since electricity was first introduced into the sphere of marine life, its use being for many years restricted to lighting.

The introduction of the electric light was soon found to be a great boon to steamship owners and ocean passengers. It presented a ready solution to many difficulties, especially in the case of passenger steamers. It reduced considerably the risk of fire from lamps and reduced to a minimum the trouble and expense of attendance.

Perhaps the strongest proof of these claims is the extensive, in fact almost universal, adoption of electric light on board ship within a very few years of its introduction.

The plant consists of one or more dynamos each connected to a high-speed engine, the whole being mounted on a combination bed-plate and placed in the engine room, generally on the bottom platform, and supplying all the lamps with current through insulated mains and sub-mains. It is pretty certain that in the case of a river steamer this is an ideal installation, requiring a minimum of attention; but in the case of an ocean-going steamer the case is obviously somewhat more complicated, because the steamer having in all weathers to go literally through the seas, the installation is very liable to suffer damage from the weather, and consequently it requires the constant care of a skilled attendant. But if one considers the disadvantages and inferiority of oil lamps, it will easily be seen that there is an immense balance in favour of electric light, and if to this is added the adaptability of electric light to decorative effects in the saloons, etc., it will be readily seen why electricity is now considered indispensable at sea.

When the electric light was first introduced there were many dismal predictions of disaster owing to the alleged effect of the current on the compasses. But although it can be shown that the current undoubtedly has an effect on the compasses, yet when due precautions are taken it seldom falsifies them more than a point or two. This error is carefully combated by the compass adjuster by the use of magnets about the ship, and as it varies somewhat, its extent and variation are both known to the officers, who allow for it accordingly. In addition there is always the standard compass, which is situated high enough above the deck to be beyond the influence of the current.

In naval service the electric current is employed very extensively, being used for lighting, including search signal lights, heating, cooking, gun-firing and gun-training, boat, ammunition and ash hoisting, engine and boiler room lifts, etc. As in large liners, the current is kept on the wires constantly, the whole of the ship below the waterline being alight day and night.

As to the different types of engine used for dynamo driving:

First, there is the single-cylinder open type. This is by far the most common type in use. It is especially adapted to the installations of small steamers. Direct connection with the

engine shaft is the universal practice at the present time. This method necessitates the use of somewhat larger dynamos than otherwise on account of the comparatively low speed of the engine. To accommodate this low speed the diameter of the armature must be increased in order that the necessary peripheral speed may be obtained. The next type is an elaboration of the first, viz., the single-cylinder enclosed type. These engines are generally fitted with a throttle valve governor, which controls the speed within 3 per cent. from no load to full load. The working faces are all lubricated, the cylinder by some form of sight-feed lubricator and the moving parts by a small pump attached to the eccentric, and connected to the parts to be lubricated by pipes, through which the oil is forced. Another type is the open-type compound with cranks at 180 degrees. These engines are fitted with an automatic crank-shaft governor, operating by varying the valve travel. The cylinder, as before, is lubricated by a sight-feed lubricator, the moving parts by oil reservoirs, those for the bearings being cast on the keeps, the gudgeon pin, crank pin, wrist pin, etc., being fed from a box on the top of the strut. A fourth type is the enclosed compound and a fifth is the steam turbine, all of which are made in all sizes.

Having said thus much about prime movers, now for a few words about the dynamos. First as to whether continuous or alternating current is the better. Although alternating current has been used on board ship, it has not yet been employed successfully. Owing to the high voltage usual in alternating current work the insulation must be of the very best. Then putting aside the question of safety, there are several things, e. g., fan motors, which cannot be operated so easily on an alternating current circuit as on a continuous current circuit. It has also been found that considerably less insulation is needed for continuous current than for alternating current on board ship. So that continuous current is practically always used; in fact, as far as the writer knows, there is not a ship afloat which is lighted by an alternating current.

The dynamo is of the multipolar type, with either four or six poles set in a cast-iron yoke. The winding is nearly always compound. The armature shafts are of steel and the bearings are fitted with loose oil rings running in an oil bath, so as to be suitable for long runs. The brush rockers are of the type for carbon brushes and are arranged so that the machine shall run sparklessly without movement of the brushes from no load to full load. The machine is so designed that after a six-hours' run no part of it will have risen more than 70 degrees Fahr. above the temperature of the dynamo room.

From the dynamo we go to the switchboard. This is the same as an ordinary lighting board except in size. It has in addition to the usual fittings a pilot lamp, and, when the ship is wired on the double-wire system, two earth lamps. The pilot lamp is connected directly across the dynamo mains, its function being to show whether the dynamo is generating or not. The earth lamps are intended to form a ready means of ascertaining whether there is any leak to earth or not. The two lamps are connected in series across the mains. They thus offer twice the resistance of a single lamp and consequently only light to half glow. Between the two lamps a connection is made to earth, i. e., to the hull of the ship, the result being that should there be a leak in, say, the positive main, the lamp between the positive main and the earth connection will be cut out of circuit while the other will burn at nearly full brightness. By turning on these lamps a glance will show whether there is any leak, and if so, in which main it exists. If there is a leak it can be found by opening each circuit switch and corresponding negative fuse one at a time. On the extinguished lamp relighting to half-glow it indicates that the fault lies in the circuit last opened. Hav-

ing thus found the circuit, the next step is to proceed to the section box and test with a galvanometer and battery. If the connection bars do not show any connection to iron, the fault lies further on, so test each pair of terminals until the faulty one is found. The next section to be tested is the distribution box fed by that pair of terminals. If on testing with battery and galvanometer the connection bars are found to be intact, the fault must lie between the distribution box and the lamps. Between which lamp and the box it exists may be found by testing the terminals until the faulty pair is found; the leak then exists either in the leads running from that pair of terminals, or in the lampholder to which they are connected, or in the switch through which they are led to the lamp. Obviously these lamps, i. e., the earth lamps, are only fitted in ships wired on the double-wire system. Perhaps a few words on the relative merits of the single and double wire systems would not be altogether out of place here. The single-wire system has the by no means inconsiderable advantage of being very much cheaper than the other, but what it gains in this respect is more than lost from the point of safety. While the former method may be safe enough, with care, for a cargo, or even for a passenger steamer, it clearly would not do for a ship which carries explosives, such as, say, a battleship. In fact, the author has been told that the various naval authorities, British and foreign, will not have anything to do with that system of wiring. In short, the single-wire system is fast going out of use, the considerations of safety being of more account than those of prime cost.

From each circuit switch on the board a pair of cables is run to a section box, which is a teak box containing six or less 10 ampere double-pole fuses, mounted in a slate base. From each pair of these fuses a pair of submains is run to a distribution box, this being a section box on a lighter scale arranged generally for eight 16-candle power lamps. From each pair of terminals in the distribution box a pair of wires is led through a 5-ampere Tumler switch to a lamp. The greatest advantage of this system of wiring (known as the distribution-box double-wire system) is that it does away entirely with soldered joints. All the wires and cables are run in entire lengths from dynamo to switchboard, switchboard to section box, section box to distribution box, distribution box to lamps. The only joints are mechanical ones, where the ends of the cables are connected to the brass terminals in the boxes and in the switches and lampholders. The cables, wires and fittings are all of special pattern. The chief feature of the cables and wires is the excessive insulation and protective material with which they are coated. The mains from the dynamo to the switchboard are covered with a sheathing of lead. The cables supplying the section boxes from the switchboard are generally protected by an armouring of steel wire in addition to the lead sheathing. This type of cable, i. e., the lead-covered and armoured, is used in all exposed positions, such as deck lights, engine and boiler room lights, etc. In the cabins the wires are supported by small brass clips spaced about 8 inches apart. In alleyways and such like portions of the ship these brass clips are replaced by heavier ones of galvanized iron, which are screwed to the bulkheads at distances of about a foot from each other. Wherever the cables pass through a bulkhead they are carried in a lead bush or else in a bulkhead gland. If it is a water-tight bulkhead they are carried in a special type of gland, which is very much the same as the stuffing box of a steam engine. When the cables pass through the deck they are carried in a deck tube. This is a length of galvanized iron pipe fitted with nuts and washers and of sufficient length to protect the cables for about a foot above the deck. For the masthead light the wires are run up the side of the mast in a galvanized iron pipe, which is carried

right into the lantern, thus effectually preventing the entry of any water.

Now, just a few words as to the distribution of the lights. In dividing up the installation into circuits one has to be guided by the anatomy of the ship (if one may use such a term). Generally the engine and boiler rooms and engineers' quarters form one circuit, the saloon and offcers' quarters, together with the staterooms when there are not many of the latter, form another; if there are many staterooms they form one or more circuits by themselves. Navigation lights, i. e., masthead, side and stern lights, etc., although not given a circuit to themselves, are all fed from one distribution box, which is reserved for them and is placed either in the wheelhouse or in the chart room. In connection with the signal or navigation lights there is also fitted an indicator which, should one of these lights be extinguished, rings a bell and indicates by a telltale which light is damaged; at the same time it automatically switches on a spare filament in the lamp, thus avoiding total extinction. The projector and arc lamps when carried have a circuit to themselves.

In lighting the saloons an attempt is often made to mask the lamps; thus in the steamship *Mauretania* the first class saloon is lighted by means of lamps hidden in the dome, so arranged that they throw their light onto a gilded convex disc in the summit of the dome. The result of this is that a soft red glow is thrown over the saloon, the effect being that of a rich red sunset. But unfortunately it is not every ship which has a convenient dome in the saloon, so the lighting has to be carried out by means of pendants, which are either polished brass or electro-plate mounted on teak blocks. This system is carried out in the officers' and passengers' accommodation also. In the men's quarters the lighting is effected by means of guarded pendants and brackets of polished brass, mounted on wood blocks.

There is one other thing to consider before leaving the question of lighting, viz., searchlights. Every war vessel carries from one to twenty of these, and every vessel of any description whatever passing through the Suez Canal has to carry one of special pattern. A searchlight consists essentially of an arc lamp of special form, a parabolic mirror and a case to hold the lot; the case being mounted so as to be capable of movement in two directions, viz., vertically and horizontally. The hood, as this case is called, is made of sheet steel about 3/32 inch thick. The turntable, trunnions, etc., are cast in gun metal, the arms which support the hood are of cast steel. The lamp box is formed as part of the hood. The mirror is carried on springs in the back cover and at the front of the hood is a "front glass" mounted in a gun-metal ring, and the dispersion lens, when carried, is hinged on in front of this. Training is carried out by means of a worm and wormwheel or by a rack and pinion. Slewing is effected by means of a pinion which gears into a crown wheel on the underside of the turntable, or else it is done directly by hand. The Suez Canal regulations require that the projector shall be capable of giving the light required under two different conditions—in the first case a broad, flat beam of light illuminating both banks and the canal uninterruptedly, this being used when no other ship is approaching; in the other case they require a beam having the same angle of divergence and consequently the same width as the first, but divided into two portions, with a dark interval between, thus giving light at both sides but not directly in front and so not interfering with the navigation of the approaching vessel. To accomplish this the projector is fitted with two lenses (one for each purpose), which are hinged on and controlled from the rear by means of rods attached to them. The Suez Canal plant is mounted in a wrought-iron cage and slung over the bows down to the waterline, a seat being provided for the operator. The lamp is so arranged that the positive carbon

(the larger one) is farthest from the mirror and the cables should line up accordingly. The hand lamp consists of a framework of steel rods which carries the two arms for the carbons, these being adjusted by means of a right and left handed screw and hand wheel. The whole lamp can be moved backwards and forwards by means of another hand wheel. In the automatic lamp these operations are carried out by means of small electric motors.

So much for electric lighting on board ship.

In the early days electric power was out of the question, because the only type of motor then built was totally unsuitable for ship work. But the modern motor is as reliable as any other power generator and is quite capable of resisting the adverse weather which is met at sea. It also takes up considerably less room than steam or hydraulic engines, and the cables take up very much less space than the necessary pipes, etc., for the other power agents. In the chief navies of the world it is now almost exclusively used for the operation of auxiliaries.

An important application of electric power on board ship is to hoisting machinery. The following are some typical examples of electrically-operated hoisting machinery. The first is a small whip such as is used for hoisting mails, passengers' luggage, ammunition, ashes, etc. This consists of a single drum driven through one set of worm gearing by a motor. The drum is loose on the shaft and is driven by a cone clutch; pawl gear inside the drum holds the load when the cone is thrown out of gear. The barrel shaft is constantly running, being driven by worm gearing from the motor. When required to hoist, the friction cone is thrown into gear by means of the clutch lever. When the load reaches the required height this lever is dropped and the load is held by an automatic self-holding brake. To lower the load the brake lever is slightly raised. Another type of hoist is a coaling hoist. This type of hoist consists of a powerful motor driving a barrel and two warping drums through one set of worm gearing. The worm gear is enclosed in an oil bath and is fitted with either a roller or a collar thrust to take up the thrust of the worm. A foot brake is fitted to the motor shaft capable of holding the full test load, which is one and a half times the working load. A heavier type of hoist is a boat hoist. This requires in general a series wound motor of the totally enclosed type fitted with powerful brakes to control the load while it is being lowered. Mechanical friction brakes, generally of the band type, are used, as are magnetic brakes. As the part they play is very important on account of the very heavy loads with which this type of hoist has to deal, special attention is paid to their design and construction. In general, a boat hoist consists of a large steel drum grooved for wire rope and driven through one set of spur and one set of worm gearing. As before, the worm runs in an oil bath and the thrust is taken by a roller bearing. Two brakes are fitted, one a foot brake and the other a magnetic brake.

For a long time motor-driven capstans and heavy winches were regarded very suspiciously, because the work which they are required to perform is exceedingly heavy and very variable. For instance, in warping a ship out of dock the load may increase suddenly from normal to three or four times its proper value, in which case the motor might be forcibly brought to a standstill with the current still on it and thus be badly damaged. At the best it would be automatically cut out of circuit, with results which can be easily imagined. One method of overcoming this difficulty is to use a series-wound motor running at constant speed and by the aid of automatic switches resistances are inserted or cut out. These resistances are put in series with the armature and allow only the maximum safe current to pass, and this is sufficient to keep the strain on the capstan head. An essentially naval application is the rotation

of the barbettes for the big guns on board a battleship. This is effected by means of shunt-wound motors connected to their load by worm and spur gearing. It is best to insert a friction clutch at some point in the gear train in order to prevent shock to the motor, etc., by the sudden impact of heavy gun fire.

The principal water-tight doors on board liners and battleships are invariably electrically operated. This is done by means of compound wound motors driving through worm and spur gearing. When the door is fully closed, an automatic arrangement lights a signal lamp in the "emergency station," which is the part of the ship from which these doors are controlled. There is a switch at each door by means of which the door can be opened from either side. There is also another switch fitted which automatically stops the motor when the door is fully closed or if it meets with any obstruction. In the latter case the door continues its journey as soon as the obstruction is removed. In a case of emergency it is possible by closing one switch in the "emergency station" to close every door in the ship. This is done by spring-driven gearing, which operates the switches at the various doors at intervals of about three seconds. Thus, without throwing too heavy a strain on the generating plant, it is possible to close, say, twenty doors in a minute without more than six motors running together.

These are the principal applications of electricity on board ship. Others of less frequent occurrences are the driving of forced-draught fans, ventilating fans, pumps, etc. Heating, cooking, bells, telephones, wireless telegraphy, are also applications of the electric current. In the case of forced-draught fans the motor is coupled directly to the fan; ventilating fans are connected in the same way, and are of all sizes, 6, 9, 12, 18, 24 being the most common. Pumps are either three-throw ram or centrifugal. The former are driven through spur gearing, the latter are direct connected to the motor. Bells and telephones are generally operated by secondary cells, the telephones being of a special loud-speaking pattern. Wireless telegraphy is carried out by one of the numerous systems now in vogue, the Marconi system being, I believe, the most general. The aerials consist of two parallel wires suspended between the masts, conductors leading from them to the operating house, which is situated generally on the bridge deck amidships.

These are about all the applications of electricity on board ship at the present time; but if one considers that this has been achieved in a little over thirty years, it seems that in the near future electricity will reign supreme on board ship.

STEEL SHEET PILING

By J. F. Springer

II. MODERN FORMS OF BUILT-UP AND ROLLED SHEET PILES.

In the last issue of this magazine Mr. Springer reviewed the development of sheet piling, discussing the various designs of timber sheeting and the intermediate forms using cast-iron piles for coffer-dams and similar work. The present article examines the latest types of steel piling of interlocking forms, including built-up piles, rolled shapes and mixed forms, with numerous examples of effective applications of this useful aid to the engineer, architect and contractor.—THE EDITOR.

BUILT-UP SHEET PILES.

THE first inception of an interlocking sheet piling formed of I-beams alternating with box members fabricated from channel bars was probably due to Simon in Germany. This idea was taken up by Geo. W. Jackson (Geo. W. Jackson, Inc., Chicago,) in this country, and applied to a very difficult piece of work in Chicago. Aside from the driving of some steel sheet piles for experimental purposes, this steel sheeting driven to form a cofferdam in the Chicago River in connection with the construction of the Randolph Street Bridge, was the first actual application of the steel sheet pile in the United States. This was in 1901. This was by no means the first case where metallic piling was used in cofferdam construction. Thus we have seen in a former portion of this article cast iron sheeting was used in England for cofferdams in the early part of the nineteenth century. But in none of these structures, apparently, was the depth of water great. Thus a style of sheeting effecting a reasonable sealing against water at a depth of, say, twelve or fifteen feet might be totally inadequate at thirty feet. The lateral pressure at fifteen feet is about 937 pounds per square foot, while at thirty feet it is, of course, about 1,874 pounds. This latter pressure is more than 12 pounds per square inch, and, of course, has a very penetrating effect upon the joints of sheet piling. However, the Jackson sheeting proved its entire serviceability in thirty feet of water. It should be remembered that this accomplishment was in connection with temporary construction where grout or concrete or other permanent seal was not employed. Indeed, it is ordinarily sufficient to fill the box members of the Jackson piling with clay.

In Fig. 1 we have represented a corner of the first of the two steel cofferdams built to enable the piers for the Randolph Street Bridge to be constructed. A building known as the Linn Block was but eighteen inches distant from the wall of the cofferdam. This building had been damaged by fire some years previously. It was thought impracticable to drive piles with safety in the immediate vicinity of this structure. And yet it was done without inconveniencing 200 employees at work within it. The cofferdams had to be of a size to accommodate a pier 73 × 80 feet. The I-beams were 18 inches wide and weighed 55 pounds per linear foot. The channels were 15 inches wide and weighed 33 pounds per foot. The lengths used are said to have been 40 feet long. As the depth of water was 30 feet, and the figure seems to show about 3 feet of sheeting above the level, we may conclude that actual penetration into the soil was a matter of about 7 feet. In order to effect the turn shown in the view, two I-beams were riveted together forming a T. It is said that the Linn Block is in

FIG. 1.—RANDOLPH STREET BRIDGE, CHICAGO. TURNING OF CORNER WITH JACKSON SHEET PILING

better condition now than before. This emphasizes the fact, which every now and again crops up, that the driving of steel sheeting is a much less violent piece of work than is the case with wooden sheet piles.

The Chicago River at the site of the Randolph Street Bridge makes a sharp turn from the East to the South. It will readily be seen that tugs in bringing their tows around this turn, passing from East to South, would be apt to lose control with the result that the tows would swing over toward the west bank. Here, however, the second pier was to be constructed. The cofferdam would then be subject to impacts from heavily laden boats leaving Chicago. It is said that in fact this western cofferdam was struck almost hourly, but did not develop any leaks. These large and deep cofferdams were heavily braced within, as may be seen by consulting Fig. 1.

It was natural, after the success at Randolph street, that when the Kinzie Street Bridge was to be constructed, the contractors should turn to the Jackson piling. In some respects the problem here was more difficult. Piles 45 feet long were driven successfully. This was in connection with the cofferdam built on the west side of the river. By filling the box members with clay, the water was successfully excluded. In Fig. 2 we have a view of this cofferdam while under construction. The pile-driver mounted on the float is in prominent view. In the middle foreground may be seen a corner pile similar to that in Fig. 1. Here, however, the one line of sheeting has not yet been put down. In Fig. 3 we have a view taken a month later, when the cofferdam is about completed and the bracing is in place. This view is taken at a point a little closer up, and does not show the transverse sheeting on the near end.

The construction of cofferdams is

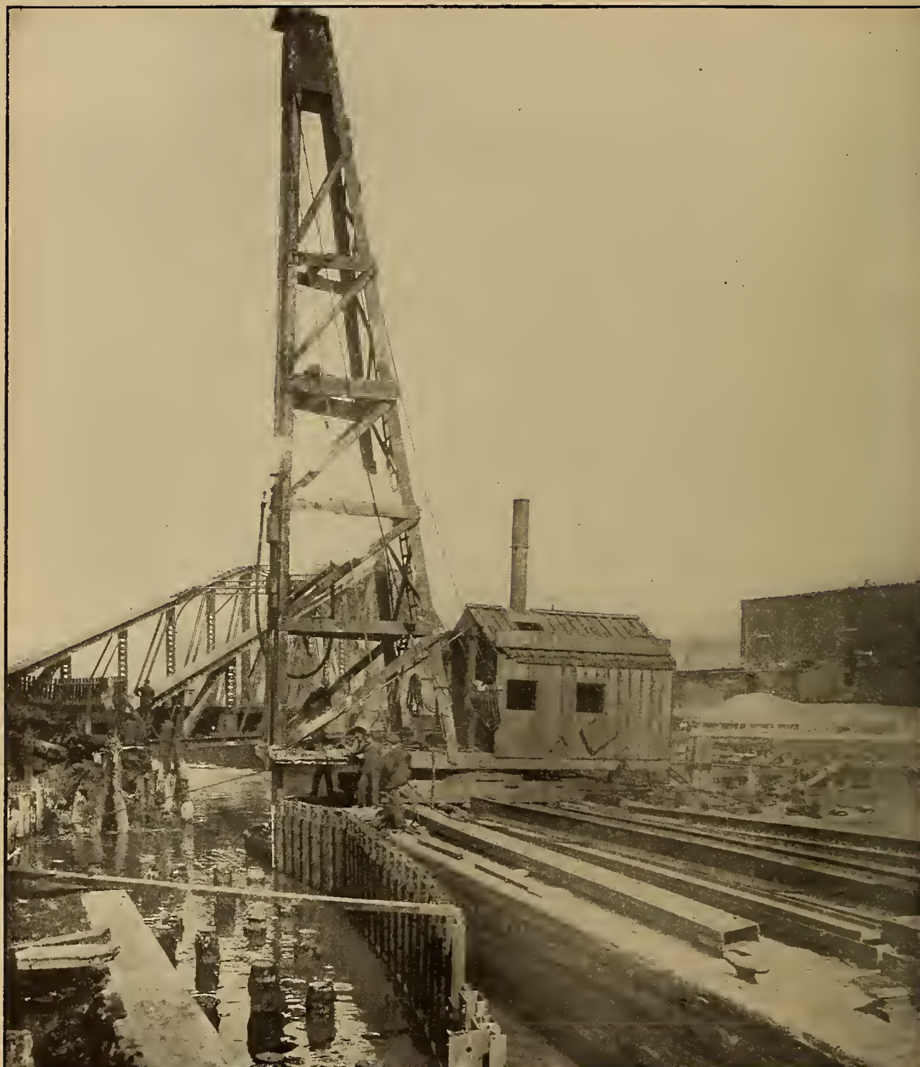


FIG. 2.—COFFER DAM AT KINZIE STREET BRIDGE, CHICAGO. JACKSON SHEET STEEL PILING

one of the most important matters that comes within the scope of an engineer's duties. Upon the successful execution of this class of work the possibility of large subaqueous piers depends. Of course, one may drive supporting piles, whether wooden, concrete or steel. But if it is desired to construct large piers on a bed-rock footing, the cofferdam and the pneumatic caisson (which is really a form of cofferdam) would seem to present the only means to attain the end desired. No doubt bearing piles have often proved quite as successful as any other mode of support. It often happens, however, that conditions render their use inadvisable. The bridge engineer is frequently face to face with the problem of deciding how he shall solve the problem of securing adequate foundations. And when he has decided, the contractor must execute.

In building a bridge across the Cumberland River at Nashville, Tenn., very considerable difficulty was experienced when the attempt was actually made to lay bare the bottom of the river for the purpose of pier construction. The contractors undertook to construct in the east channel a large wooden cofferdam. The depth of water here was not so great as was the case in the cofferdams already referred to as employed at Chicago. But the soil was of an uncertain character. The wooden cofferdam was of the crib form and had a puddle space 16 feet in thickness. This was filled in with sand and gravel from the river bed. But in spite of the generous thickness allowed for the puddle, the efforts to pump out the dam were unsuccessful. The contractors then drove a double wall of wooden sheeting consisting of 3 × 10-inch planks. They were still unable to clear the dam of water. Two 10-inch and one 6-inch centrifugal pumps were used in the effort to pump out the dam. They were able, however, to lower the level but a few feet. This was in the fall. Upon resumption of work in the following year—about June— a wall of Jackson sheeting was driven around the dam. The box members were filled with clay, and a few sacks of earth were placed at intervals along the bottom on the outside. The cofferdam was then found to be watertight. The interior was pumped dry and the concrete placed in position for the pier. This steel cofferdam was of considerable dimensions —62 × 114 feet. The channel bars were of 12-inch width, and the I-beams, apparently of the same size. The lengths used were of 25 feet. The material through which penetration was had was gravel, quicksand and boulders.

In Fig. 4 we have a view of the completed cofferdam. In the background may be seen piers and scaffolding of a landward end of the bridge. In Fig. 5 the work of with-

FIG. 3.—COFFER DAM CONSTRUCTION WITH JACKSON STEEL SHEET PILING AT KINZIE STREET BRIDGE

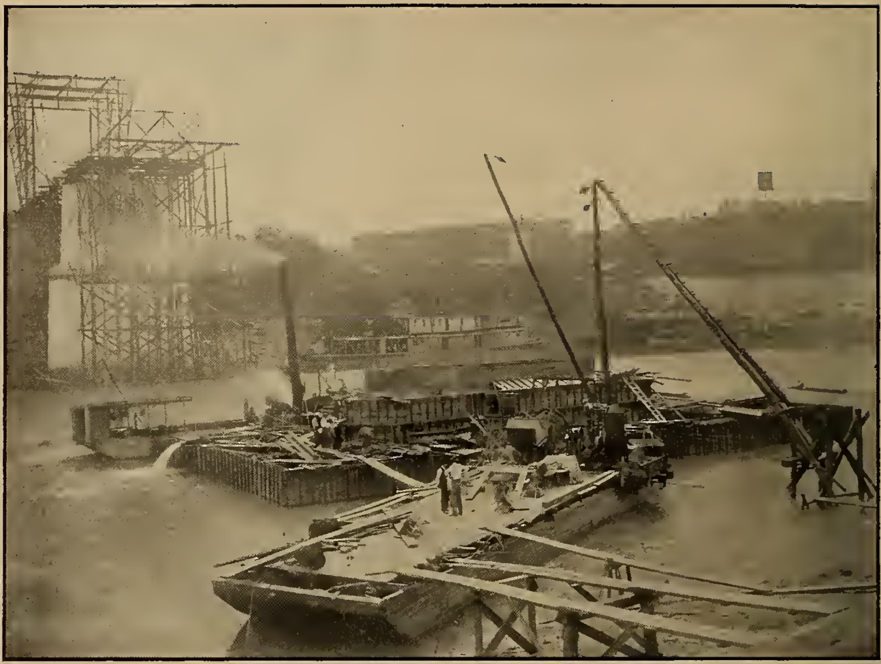


FIG. 4.—CONSTRUCTION OF THE CUMBERLAND RIVER BRIDGE, AT NASHVILLE, WITH THE JACKSON SHEET STEEL PILING

drawing the piling is going on. This brings to mind one of the most notable features of steel sheeting. It can be used again. Consequently, it has a high salvage value. So that while the first cost may seem considerable, we must take into account the fact that the sheeting is, ordinarily, but little damaged. And further, as compared with wooden sheeting, it can be driven with ease. In fact, it can often be driven in situations where wooden forms cannot be used at all. We balance aginst the first cost, then, two items: (1) the salvage value, and (2) the saving in driving. In the present case at Nashville, we have the controlling consideration that wooden sheeting failed to accomplish the object in view. It is interesting to learn the reason for the few sacks of earth that were found necessary even with the steel sheeting in order to get watertightness. When the bottom of the river was laid bare inside the dam, it was found to be corrugated. Fig. 6 shows the dam at a time when the steel sheeting was being withdrawn and loaded on scow so as to be available elsewhere on the river.

In a modified form the channel bars are quite narrow. Their service in this type is not so much to furnish a large element of stiffness, but to supply a secure interlock and a means of sealing against water. Spacing irons are not used here. Instead, a piece of timber is used both for the purpose of holding the channels at a proper distance apart and of effecting a seal against water. When this style of piling is used in shaft work, it is put in position with the nuts of the bolts on the interior. Closure against water is secured by tightening up these nuts. This is a lighter type of sheeting than the form shown as having been applied at Chicago and Nashville. Thus, the channels are 5 inches in width and weigh but 6½ pounds per linear foot; and the I-beams are 9 inches wide and weigh 21 pounds per

FIG. 5.—JACKSON SHEET PILING WORK, AT NASHVILLE, WITHDRAWING PILES AFTER USE

foot. Assembled, the sheeting weighs 33 pounds per square foot. As an example of the use of this form may be cited a shaft at Washburne and Blue Island avenues, Chicago. This shaft is 40 feet deep and 12 feet in diameter. Two sections of piling were used, but absolutely no bracing. One ring of sheeting was driven inside the other. There are, in all, four such shafts, all of them constructed for the Department of Public Works, Chicago. The adaptability of such piling for circular shafts will readily be granted when we consider that the curvature may be secured by suitably bending the I-beams alone.

We may note another example of the heavy sheeting used for a circular shaft. This shaft is 22 feet in diameter. The piling was used in 50-foot lengths to act as a retaining wall

against quicksand and clay. The entire shaft is 147 feet deep and connects the surface with the Southwest Land Tunnel, Chicago. This tunnel lies 140 feet below the surface and extends from a point a quarter of a mile back from the shore out two miles beneath the waters of Lake Michigan. The channels used for the sheet piling were 12 inches in width. Steel shields were employed for the remainder of the shaft which passes ing strata. Six such pieces were employed. They act, no doubt, as land ties in the clay stratum. This large circle—about 69 feet in circumference—maintains its form without the assistance of braces. It is located at Seventy-third street and Bond avenue. In this mode of construction the sheeting is first driven. The interior may then be excavated. It is not necessary that the circle of piling be driven as a whole. Thus, in

FIG. 6.—CONSTRUCTION WITH JACKSON STEEL SHEET PILING AT NASHVILLE. REMOVING THE PILING FOR USE ELSEWHERE

through a stratum of limestone. As the piling was put in as permanent construction, a cement grout was used to effect a seal against the water and sand. It is said to be absolutely watertight. A special feature to be noted in this circular wall of piling is the use of auxiliary I-beams at intervals. These have each one of its flanges secured to the web of an I-beam in the wall of sheeting, and extends outward into the surround- driving the piles at this shaft, part of them were sunk to position with others at a considerably less advanced stage of penetration.

There is a still lighter form of Jackson piling. Except for certain clamps, this sheeting consists entirely of I-beams. For temporary work where the service is light, this form seems to be a very admirable one. This type formed part of a cofferdam used in the construction of a very

large building in Chicago. This structure—the Steele-Wedeles Building—was being constructed along the river front. The river at this point has a minimum depth of about 22 feet. A railroad in perpetual use was located at the other end of the site. Upon one side was a large warehouse and on the other the steel structure of the viaduct approach to one end of the Dearborn street bridge. The construction of any large building upon a site surrounded with such difficulties is somewhat of an undertaking. But it was necessary here to carry the sub-basement down a distance of five stories in order to be able to make proper connections with the system of tunnels of the Illinois Tunnel Co. To meet the engineering difficulties, it was decided to employ the open cofferdam construction. The dimensions of the steel cofferdam thus driven were 40 and 132 feet. The length of the piling was 45 feet. As the sheeting weighed 34 pounds per square foot, including the locking clips, we have for the entire weight in the cofferdam proper about 260 short tons. The I-beams used were 12 inches in width.

The method of securing the beams together is as follows: For any pair of adjacent flanges a single pair of clips is used at the top and a single pair at the bottom. Both members of the lower pair are secured to the pile driven subsequently to the other. Both members of the upper pair are secured to this latter. As these clips are of forged steel and are bolted on, a very effective interlock is secured. In driving, the I-beam last in place may have its double clip at the top already bolted on before another I-beam is driven. This last may, accordingly, be started with the inner flange in engagement with the double clip. When the lower end of this pile has gotten well past the double clip, a pair of clips may be secured to it in such a way as to clasp the pile in place. As driving now goes on, the new pile will be guided to its proper position.

At the Steele-Wedeles Building this sheeting was first driven to form the walls of the cofferdam, when excavation was proceeded with. Penetration was secured by the use of a two-ton Vulcan steam hammer. The soil was quicksand underlaid by a soft blue clay. As penetration continued, however, the clay became stiffer until a stratum of hardpan was reached. This wall of piling was left in the ground. It is estimated that the sheeting itself cost about 40 cents per square foot. The expense of driving amounted to something over 2 cents per square foot. When the excavation was carried out an opportunity was afforded of noticing whether alignment had been maintained. It was found that it had.

A great advantage of the Jackson forms of sheet-piles is the fact that they are all fabricated from standard architectural shapes. By paying a royalty the material may be purchased in the open market and the piling made and used. Or it may be bought direct. And in either case the piling has a large salvage value when used for temporary construction, as it is usable for ordinary structural purposes after being withdrawn from the soil.

THE INTERLOCKING CHANNEL BAR PILING.

The form invented by Simon in Germany for use at the mines of the New Hope Company, and later on taken up by Jackson in this country and certain other forms controlled by the Geo. Jackson Company, have not been the only types of steel sheeting fabricated from structural shapes which have been developed and successfully introduced into engineering practice. The Carnegie Steel Company controls two types of fabricated sheeting. In all the forms which we have heretofore been considering the I-beam has been a vital element. But in the two Carnegie styles the I-beam has no place. The channel bar and the Z-bar are the only shapes which enter. In the one form every alter-

FIG. 7.—SEA-WALL AT FORT PHILIP. CARNEGIE SHEET STEEL PILING

nate member of a wall of sheeting is a simple unaltered channel bar. The remaining alternate members are also channel bars, but ones to which Z-bars have been riveted. That is, two Z-bars have, each, one of its flanges riveted to the face of the web within the channel in such way as to form at either side of the channel bar an interlocking space suited to receive and retain a flange of a reversed and adjacent channel bar. It will be observed that the form of the interlock is such as not to permit withdrawal except in a vertical direction. If there is a bulging action of the soil upon a wall of sheeting of this type, the interlock must actually be broken to permit the escape of an actual member. In the second style of channel bar piling the interlock is still stronger. Here two channel-bar flanges are clasped between a pair of Z-bars. This arrangement is secured simply by replacing the unaltered channel bars of the first type by members identical with those formed of a channel bar with two Z-bars riveted to it. In other words—in the second form of channel-bar sheeting all the members are precisely alike. However, it may seem unnecessary to extend the Z-bars the full length of the alternate members. In this case—which is the usual one—the statement that all members are precisely the same would need modification. When it is desired to turn a corner with either style of piling it is only necessary to cut one of the members in two longitudinally and then re-unite them at the desired angle by means of an angle bar.

It will be observed that a wall constructed of interlocking channel bar piling will have a fluted appearance. A little consideration will convince one that this form of wall is one of considerable stiffness. That the joints are fairly watertight will, perhaps, be readily granted, although there is no distinct provision for the use of a seal of clay or other similar material.

But that leakage is not large, apart from any especial sealing, even with a rather considerable head of water, may be gathered from the successful use in a cofferdam employed in the construction of the Kinzie Street Bridge at Chicago. It will be remembered that one of the Jackson types was also used in cofferdam

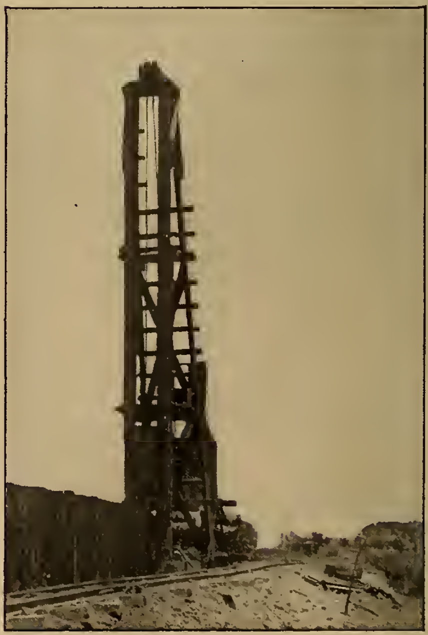


FIG. 8.—PILE DRIVER SETTING, CARNEGIE SHEET PILES

FIG. 9.—HAMILTON-PIERCE HAMMER, DRIVING STEEL SHEET PILING AT MUNICIPAL BUILDING, NEW YORK CITY

work in connection with the same bridge. Here a large cofferdam was constructed of the simpler form of channel-bar sheeting known by the trade name of the Friestedt Interlocking Channel Bar Piling. The sheeting used had all been employed six or seven times previously. Nevertheless, the sealing against water was so complete that a 3-inch centrifugal pump working about 8 or 9 per cent of the time was competent to keep the cofferdam clear. The second type of channel-bar sheeting, known by the trade name of the Symmetrical Interlock Channel Bar Piling, was employed in a cofferdam at Pittsburg, where the depth of water at the site was 30 feet, and where, consequently, a leakage pres-

sure of 13 pounds per square inch had to be guarded against. Of course, this same pressure was also operative against the piling considered as a wall. These appear to be the reasons for the selection of the second form rather than the first.

We have already seen that the press of conditions in sinking a mining shaft in Germany led to the invention and successful use of a type of steel sheet-piling. Similar conditions in the United States were likewise conquered by the employment of the Friestedt piles. The Robert Gage Coal Company desired to sink a vertical shaft near Auburn, Mich. Proceeding in the usual way, those in charge of the work successfully penetrated a 50-foot stratum of clay. Beneath this was a thick layer of gravel and sand. This yielded water in very considerable quantities. No difficulty seems to have been experienced in taking care of this water. But so much solid material would come away with it that the overlying stratum became insufficiently supported. Upon its collapse the timbering was broken and the alignment of the shaft lost. This was the first attempt. Two others likewise failed, the three having cost, as Mr. Coryell, the vice-president, says, upwards of $75,000. It was then determined to make a fourth attempt with steel sheeting. The clay stratum and about 10 feet of the sand were penetrated by usual methods. At the bottom of this excavation—60 feet below the suface—the steel piles were now driven in 20-foot lengths to and into the underlying slate rock. The penetration into the slate amounted to about 1½ feet and thus effected a good bottom joint. The piling could not well be driven in 20-foot units, so sections of 5 and 10 feet were employed. These were arranged with a view of breaking horizontal joints. The joints themselves were made watertight by interposing a strip of copper. A plate would be bolted on to secure the two sections together. The reason the full length could not at once be driven was because of the obstruction of the timbering. When the circuit was complete, the cofferdam was excavated. As the material within was taken away, the rectangular walls were braced by timbers. The size of this shaft was 7 x 14 feet in the clear. To drive the piles having their heads so far below the surface, a drilling machine was employed to operate a jerk-line to which was secured a 1600-pound hammer. Special means were adopted to direct the hammer. These consisted of sheaves and a sheet steel pipe

This example from the *Engineering News* is chiefly valuable as confirmatory of the German experiences that it is possible to pass successfully an underlying water-bearing stratum. In the present case this stratum was at a very considerable depth. We are not informed as to whether the water was under a hydrostatic head reaching up towards the general surface, and so are unable to judge of the lateral thrust against the steel wall. However, this is a matter for which provision can be made in any particular case by using a suitable weight of sheeting and employing an adequate system of bracing. The head could, of course, be predetermined by drilling.

THE ROLLED FORMS.

The dependence of our present material civilization upon the rolling mill is very marked. Rails, strucural shapes, plates, bars both round and not—all are the product of this device. Apart from casting, it seems to be the only practical method of producing such steel forms in large quantities at an economic price. And it is doubtful whether the process of casting could be brought to show the same economic advantage. But the objection that cast steel does not have the same tensile and shearing resistance is sufficient to retard its employment in the large production of fundamental forms. In fact, the rolling mill is here supreme, and promises to remain so for some time yet.

Now these considerations have had their effect in the development of metallic sheet piling. The cast iron sheet pile has probably had its last large installation. Besides, it never did seriously threaten wood sheeting. No sheeting can now hope for extensive adoption that does not admit of more or less direct production by the rolling mill. The fabricated forms, such as the Jackson and Friestedt pilings, are built up from rolling mill products. So are such types as the corrugated sheeting. But inventors have, by no means, been content thus to use the rolling mill in an indirect way. They have sought to produce a piling that would be complete when it left the rolls. There is one cardinal advantage in piles produced thus. They are absolutely free from bolt and rivet heads. There is thus no danger of parts being stripped off or the connection becoming weakened through corrosion. Further, the piling which is finished when it leaves the mill has, in the very nature of the case, no protuberances on the surface to interfere with the driving operation. Now, of course, one might easily exaggerate the importance of these considerations. But, whatever their exact value, these advantages have a real existence. Their weight belongs upon the side of the rolled pile. Over against them, we should have to consider, no doubt, whether they have been gained at the sacrifice of other qualities more valuable still.

FIG. 10.—UNITED STATES STEEL SHEET PILING WORK AT THE PLANT OF THE SOUTHERN WISCONSIN POWER COMPANY, KILBOURN, WIS.

Three types of rolled sheet-piles have been developed in America. These are the United States Sheet Pile, the Lackawanna Steel Sheet Piling and the Jones & Laughlin Steel Sheet Piling. In the case of every one of these, the piling is absolutely complete when it comes from the rolls. The oldest form is the first named. There have been other types designed, but apparently the very first pile to be actually rolled

was of the Behrend form. This is the United States pile. But while this *design* was patented in 1899, it was not successfully *rolled* through the mill until 1904—five years later. In fact, an especial method of rolling had, apparently, to be developed before actual execution of the design could take place.

Its essentials are a web having at one side two flanges arranged to form a kind of clasp and a pair of small flange-like projects upon the other side. When, in assembling such piling, the clasp-like flanges envelop the others, a positive interlock is formed, permitting the removal of one pile from the other by a vertical movement. Further, a space is left in the interlock suited to the reception of some sealing material as wood, clay, cement, grout, or the like.

But to roll this section proved a formidable proposition. This seems to have chiefly concerned the development of sufficient material in the two flanges to form the clasp or of the development of it at a suitable angle to the web. However, through the ingenuity of an inventor by the name of Slick, the rolling mill difficulties were ultimately overcome.

One of the most important uses to which metallic sheeting has been put is in connection with the formation of curtain or core walls for dams and the like. The Behrend piling was employed by the United States government for the core of a levee protecting Fort St. Philip in southern Louisiana from the waters of the Gulf of Mexico. Because of the possibilities of high water occasionally, it seemed desirable to extend

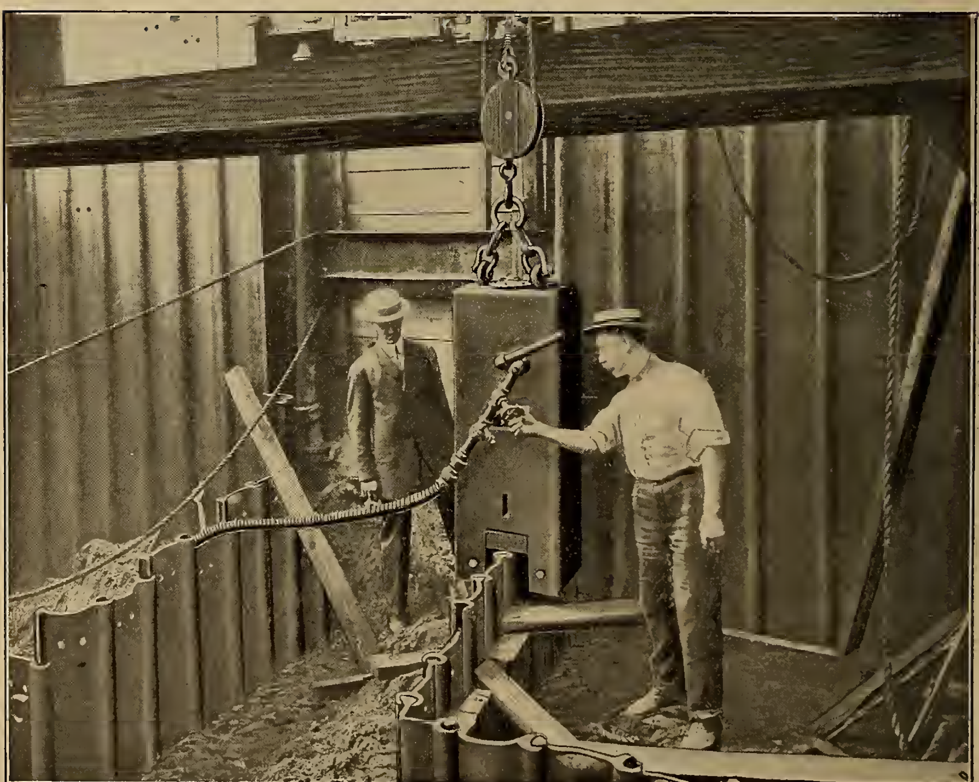


FIG. 11.—UNITED STATES SHEET PILING BEING DRIVEN BY ARNOTT STEAM PILE HAMMER, TO FORM OPEN CAISSONS. UNION IRON WORKS, HOBOKEN

FIG. 12.—COFFERDAM CONSTRUCTION FOR POPE BUILDING, CLEVELAND, OHIO. UNITED STATES SHEET PILING

the bulwark of the levee upwards in the form of a reinforced concrete sea wall. The steel piling when installed was used in such lengths that, with sufficient penetration for the purposes of the core wall, the upper ends would form a kind of steel fence four or five feet high. This was used as a central core for the concrete wall.

Of course, the use of steel sheeting for such work is not limited to a particular form. Undoubtedly, there will be a considerable use of steel sheet-piles in levee construction and repair.

The function of the sheeting in the body of a levee is quite important. Its office is to prevent the formation of lines of seepage. A current of water once started may quickly enlarge its passage and so lead to the ultimate collapse of the entire work. Some of us, no doubt, remember the old story of the little boy in Holland who once when alone discovered that the sea had penetrated one of the dykes by a small hole. Alive to the instant danger, he closed the hole with his arm and made a hero of himself through his presence of mind. Well, the steel sheeting in a levee is the Holland hero ever on the spot. It prevents the initial formation of a hole penetrating the body of the levee transversely. In some sections of the country, such a hole might be actually constructed by a burrowing animal. The wall of steel effectually intervenes and either entirely prevents the hole being constructed or limits its size. But a very serious question enters here. How shall we prevent the destruction of the steel sheeting through corrosion? It is of but little use to construct a curtain wall which will soon rust out. We have, then, to prevent this action. We might think to envelop the piling in a more or less thick coating of thick concrete. But the difficulty of forming this is in its way. It has been proposed to cover merely the upper portion of such a wall with concrete. The reason for the possibility of this limitation is the principle, which has

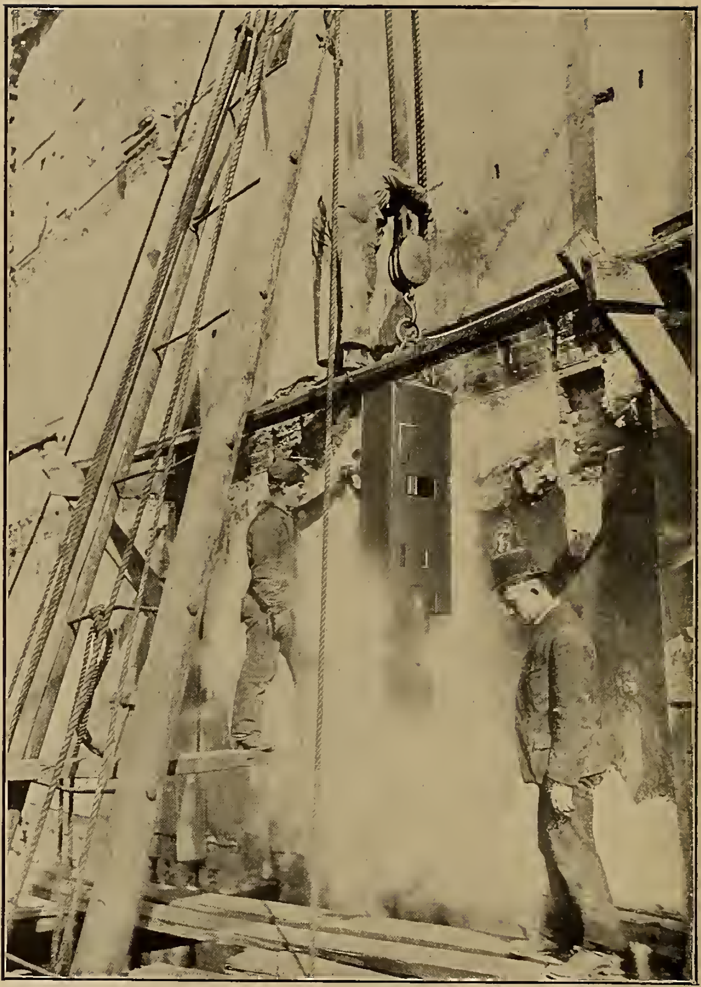


FIG. 13.—ARNOTT STEAM PILE HAMMER SUSPENDED FROM DERRICK FOR DRIVING STEEL SHEET PILING. UNION IRON WORKS, HOBOKEN

been pretty well determined, that it is ordinarily necessary for both water and air to be present to effect corrosion. If steel is immersed in quiet water, the only source of air is that which has been trapped by the water. At a not very considerable depth, the amount of this is *nil* or at least negligible. Now in levee, and other construction, the excavation front and back of a curtain wall might be very practicable for a moderate depth. So that a cap of concrete may often be placed economically upon the upper portion. The lower section of the wall would depend upon the absence of air for its preservation. The heavier varieties of steel sheeting would appear very suitable for use in the formation of such curtain walls in levees and under dams and the like. Sheet piling would seem quite adaptable to the construction of core walls of concrete. If conditions of penetration are such that thin sheeting can be used, an economical method appears to be to drive a double line of piling and excavate between. The space could then be filled with concrete. With a substan-

tial wall of concrete, it would be a matter of indifference whether the steel corroded or not.

But let us return to the consideration of the specially rolled pile known as the United States sheeting. The appearance of a wall formed of this type of piling is quite flat and smooth. This is well shown in Fig. 10, where a dam is being constructed for the Southern Wisconsin Power Company at Kilbourn, Wis. This company employed 176 tons of the heaviest weight, in lengths varying from 15 to 40 feet. The soil penetrated seems to have been mostly sand, so that the conditions were probably not severe. With the use of a 2000-pound drop hammer, penetration was accomplished at about 10 cents per foot.

In New York City the frequent presence of quicksand on the building sites of lower Manhattan seriously complicates foundation problems. Not only must the quicksand be penetrated, but surrounding buildings must be preserved from settlement. This has led to the common use of the pneumatic caisson. It would seem that other cities are not necessarily exempt from similar difficulties as those experienced in lower New York. For, in constructing the Pope Building in Cleveland, Ohio, a thick bed of quicksand was met. For some reason the use of compressed air was deemed inadvisable. In order to overcome the conditions, a retaining wall of sheet piling was put down, enclosing the whole area of excavation. The 35-pound weight was used, the driving being accomplished with steam and drop hammers. The feet of the piles were well sealed in four feet of clay. Above this were 27 feet of quicksand and 4 feet of sand and water. There was thus a hydrostatic head of 31 feet. The cofferdam is said to have been practically watertight. Just what means, if any were used to seal the sheeting, the writer is not aware. The interior of this cofferdam is shown in our illustration. It would seem that the presence of the stratum of clay contributed largely to the success here.

Mention has already been made of the deviation in alignment possible with the unaltered forms of this piling. Indeed, with the 6-inch section, a variation of about 24 degrees is possible, and with the 35-pound weight of the 12-inch size about the same. With the 40-pound, 12-inch size, the angle of deviation is about 18 degrees. It will be seen from the facts that cofferdams, pump wells, foundation pits and the like can be constructed in circular form without modification of the piling. Pretty much all styles of steel sheeting admit of some angular deviation, and so could be used when the circle is very large. The advantage of a large possible variation becomes evident when the circle is quite small. The Baltimore, Chesapeake & Atlantic Railway constructed a permanent circular shell for a bridge pier at Ocean City, Md., whose diameter was but 18 1-3 feet. The 6-inch, 11-pound form was used, but the heaviest might have been. This shell is 25 feet deep and has served the purpose of a mold for the concrete. It is now performing the additional duty of a protective covering against the action of the ocean.

One great advantage in the use of steel sheeting in the construction of dams and the like consists in the fact that it may be installed without excavation. An example of such use of steel piles is the dam for the Pondera Canal at Heins Coulee, Montana. Here it was employed to form a permanent core wall at the deepest point of the dam and was driven to rock. Concrete masonry overlies it. Reliance is thus put upon this diaphragm of steel for an indefinite time.

Attention has already been called to difficulties which arise in foundation work in cities where qucksand may have to be dealt with. These difficulties relate largely to the preservation of neighboring buildings. Now this same duty may arise in connection with clay. Thus, in construct-

FIG. 14.—LACKAWANNA ROLLED SHEET PILES IN YARD.

FIG. 15.—TRENCH CONSTRUCTION WITH LACKAWANNA ROLLED SHEET PILES

FIG. 16.—COFFERDAM WITH STEEL SHEET PILING AT BLACK ROCK HARBOUR

ing the foundations for the New Brevoort Hotel, Chicago, it was feared that if excavations of five-foot sections were made through the clay and then lined with wooden lagging, the material might slip during its unsupported period and thus endanger structures beyond the site. To meet this condition small cofferdams of sheet piling were driven to a depth of 30 feet, thus passing the clay. These cofferdams were 5 feet in diameter. The clay would be excavated and the mold thus left filled with concrete. This application was one of the first to which this rolled piling was put.

The Lackawanna Steel Sheet Piling is another rolled form developed in America. The form of its cross-section will be seen in the illustrations. It will be seen that this is symmetrical as to right and left, but not as to front and back. The two flanges which go to form the clasp at each side of a pile are not at all alike. The result is a rather peculiar form. When assembled in a wall, the piles are alternately reversed as to front and back. The interlock resists removal except in the vertical direction. It will be observed that an angular deviation of the alignment is possible. With the heaviest section, this deviaton may be 22 degrees. A complete crcle may be constructed with a diameter as small as six feet. With the smallest section, the permissible deviation is less, being 18 degrees, but the reduced width more than compensates for this, so that a circle of less than 4½ feet in diameter may be constructed. In one of the figures showing the first shipment of this piling, the section is well seen. This shipment was made only about two years ago, so that it will be understood that the form is commercially a new one.

However, this sheeting has already been employed in a very important piece of construction by the United States government. A large concrete lock was to be constructed at Black

Rock Harbor. In order to lay bare the site, it was determined to construct a great cofferdam. This structure was of the double form and had bulkheads connecting the inner and outer walls. The whole was thus divided into a considerable number of compartments. With the exception of one or two of these compartments the entire cofferdam was built of this one style of piling. The amount of sheeting used here makes it a notable application. Altogether, about 7,000 tons were used. The cofferdam was approximately rectangular in plan, having an external length of about 950 feet and a width of 260 feet. The piling was driven to bed rock about 40 feet below the surface of the water and penetrating soil of considerable depth, as the water at the site had a maximum depth of only about 15 feet. The many compartments were filled with clay. It will be seen that where the depth of water was considerable, the clay contained in the compartments would exert a very considerable bulging action, which would put the interlocks to a severe test, especially upon removal of the water inside the cofferdam. So far as the writer is aware, the piling has successfully withstood this tensile strain. In one of the figures the general appearance inside the cofferdam is disclosed when the water level was 29 feet below normal. The weight of piling used here was 40 pounds per square foot assembled. That this style of piling has a very strong interlock would seem to be indicated by tests of the interlock in tension. Thus the 12¾-inch section is said to have proved capable of resisting a tensile stress in the interlock amounting to about 9,700 pounds per linear inch of pile, and the 7-inch section a tension of about 6,500 pounds per linear inch.

In order to turn corners, the makers recommend the practice of uniting the two halves of a longitudinally divided pile by means of an angle bar or of the one half to the web of a whole pile by means of two angle bars. But there seems no good reason why the web itself should not be longitudinally bent—as in the United States sheet-pile.

There is a third type of rolled sheeting—the Jones & Laughlin piling. This consists of two forms. There is the section which constitutes the bulk of the wall surface. This is identical with the ordinary I-beam. Alternating with these are locking bars which are used to hold adjacent I-beams together. This is also a rolled shape. This type of piling agrees with the two last described in being a finished product when it comes from the rolls. It differs in the circumstance that two distinct units are employed. One unit consists of the I-beam and the other of the locking bar.

There is a strong economic advantage which this piling possesses in cases where its use is purely temporary. The I-beams are standard structural shapes and therefore have a high salvage value. The locking bars may have to be sold as scrap. But they constitute but a fraction of the weight of the sheeting as a whole.

It will be observed that deviations in rectilinear alignment cannot be made at the interlock. They may be made, however, in the web of the I-beam. This rigidity of the interlock is, in some respects, a decided advantage. For it enables the alignment of the new pile to be secured from the interlock with the locking bar of the pile last driven. In driving, I-beam and lock bar are handled as a unit. The two are shipped in this way and so are already assembled. The locking bar is made a couple of inches longer than the I-beam. This excess permits hammering down of the clips at each end and thus securing the I-beam. When actual driving begins, the first blow or two brings the upper ends flush with each other.

As to watertightness, dependence must be put upon the closeness and extent of the joints. For many cases of temporary construction the sheet-

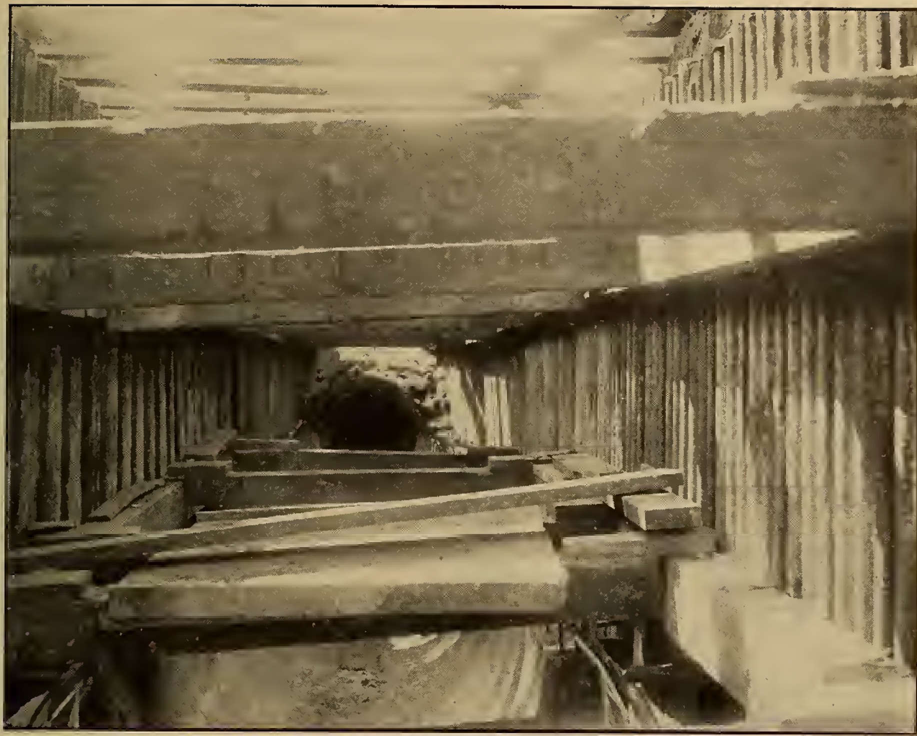


FIG. 17.—BRONX VALLEY SEWER, NEW YORK, SHOWING ⅛ SHEETING IN SAND AND GRAVEL. THE SAME SHEETING WAS USED AND REUSED DURING TWO YEARS.
WEMLINGER STEEL PILING COMPANY

ing in the present form is, no doubt, sufficiently impermeable. For severe conditions, where it is desired to have an absolutely perfect and permanent joint, some modification may seem necessary. The piling is just coming onto the market and has, consequently, had but little time to demonstrate itself. The patent covering the form was only recently (Oct. 13, 1908) issued. But the invention itself dates a number of years further back. Five sizes are now obtainable. These are made up from 12-inch and 15-inch I-beams with web thicknesses varying from 0.344 inch to 0.500 inch. The depth of the I-beams varies with each size of sheeting, ranging from 3.940 inches to 4.870 inches. The extreme dimension of the locking bar has but two values, 5 and 6 inches, corresponding to the widths of the I-beams. The weights per square foot of assembled sheeting run from 35 to 42¼ pounds.

Recently about 170 short tons of this piling were driven to form the core wall of an irrigation dam in Idaho. 15-inch I-beams and special 7-inch locking bars were employed. Through the courtesy of the J. G. White Company, the contractors, it is possible to give some details. About twenty miles to the north of Shoshone, where the Big Wood River passes through a canyon, the distance from wall to wall is comparatively narrow. Here it was decided to locate the Magic Reservoir dam. This structure is to have a width of 400 feet at the crest and a maximum depth of 135 feet, and to be of the earth-and-rock-fill type. In order to prevent or restrict seepage beneath the dam, it was determined to drive a wall of steel sheeting to bed rock.

The maximum depth to which it has been found necessary to drive the piling was 30 feet. As the piles are 35 feet long, this leaves a wall for projection into the fill of the dam of a maximum height of 5 feet. The total length of the piles used amounted to 6184 feet. The weight was 339,754 lb. These items give, on the assumption that I-beams and locking bar combined have a width of 15.25 inches, a weight per square foot of about 43¼ pounds. As the standard form with 6-inch locking bar and 15-inch I-beam with ½-inch web weighs 42¼ pounds per square feet, it is judged that the web of the I-beams used at the dam is ½ inch in thickness.

In driving this piling, considerable difficulty was experienced. The gravel being penetrated was of such a character that frequently it was not easy to get the piles down without bending them. This bending action would take place just beneath the driving cap. It would thus seem that the 15-inch I-beam with ½-inch web was not sufficiently stiff for the conditions. In the light of this experience it might seem desirable upon a similar occasion to use a narrower 12-inch I-beam with deep flanges and heavy web. A further difficulty experienced was in connection with the maintenance of verticality. Jacks and braces were employed and were found of assistance. This experience, attributed to the coarseness of the gravel and presence of boulders, does not seem to have any especial relation to the particular type of steel sheeting. In fact, one would rather expect that the rigidity of the interlock assisted in maintaining verticality. If this is the case, the trouble would have been accentuated with forms where the interlock is more flexible. Steel sheeting was selected for this work, partly because it was thought impracticable to drive wooden piling to the depth necessary to reach rock and partly because an equal tightness of joints was thought impossible with wood. Further, it is judged that the steel core wall may be expected to have a longer life than would a wooden one. The steel sheeting was not found to be absolutely watertight, although the leakage is said to have been small.

The driving was accomplished by means of an 1,800-pound drop hammer. It is thought, however, that a steam hammer would have been better. If maintenance of pile driver be excluded, the cost of driving the 6,184 feet totalled $2,355.75. This expense includes labour and material used in the driving. It is an average of $0.3809 per linear foot. The length of this steel core wall is 271 feet. It extends from one side of the cañyon to the other. It will be remembered, perhaps, that at the Hodbarrow Mines penetration of piles two feet broad into every difficult material was secured with a peculiar shaped foot. No doubt other factors entered, but we can hardly escape the conclusion that the points of the foot must have been of assistance. It would seem well worth testing then, whether blunt points at the bottom of such a pile as the Jones & Laughlin form would not be of decided advantage. The web of the I-beam could be shaped to the form of a blunt V at the bottom, and the same shape could also be given to the lower ends of the flanges and the locking bar. The opportunity for clearance thus provided would seem of real advantage in promoting penetration.

MIXED FORMS.

We have, so far, been dealing either with specially rolled forms or with those fabricated form structural shapes and plates. There is still another distinct class of steel piling. This type is formed from sheets by the aid of machinery. There may, perhaps, be a certain amount of fabrication in addition, as where a locking strip is riveted on. Prominent among this class is the style of sheeting known as the Wemlinger Steel Sheet Piling. There are two

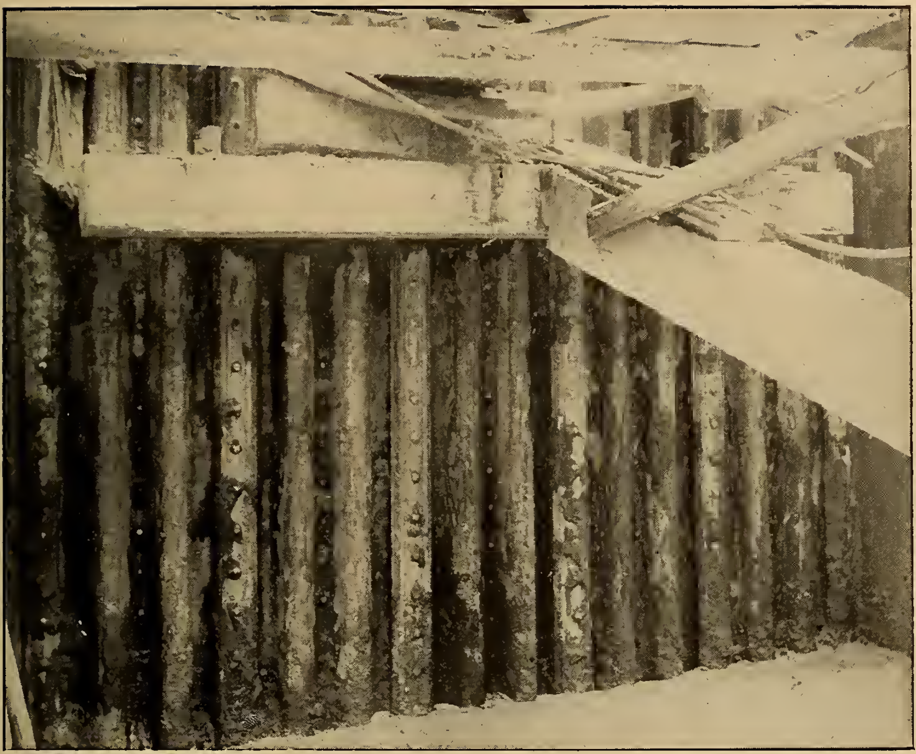


FIG. 18.—FOUNDATIONS OF NATIONAL CITY BANK, NEW YORK CITY. VIEW SHOWING WEMLINGER CORRUGATED SHEET PILING, AFTER EXCAVATION.

In this case the piling is supporting the entire pressure, due to the weight of a very heavy masonry wall, about 50 feet high, and a head of 10 feet of water. The dryness of the mud and sand, showing shovel marks, indicates the absence of leakage of water through the piling. Concrete is being placed against the steel piling.

principle varieties differing in interlocking arrangement and in the consequent mode of assembling the units. But the basic element in each is the corrugated strip of steel plate. The corrugations are longitudinal of course. The object of their use is to impart stiffness and strength. It will be understood at once that such piling has a large economic advantage, for the reason that from the multiplicity of thicknesses of steel plate readily obtainable, a corresponding multiplicity of weights of piling can be supplied. In other words, an engineer can economically secure just the sheeting to meet his particular conditions. However, it is at present not made heavier than ⅝-inch.

Whether this piling is suited for cofferdams where water under considerable heads is to be excluded may be doubted. With this exception it would seem applicable to all uses within its range of stiffness and strength.

Now it is upon stiffness that the capability of driving largely depends. It would seem that from this point of view the corrugated sheeting is one of the best possible types. In fact, it is claimed to be absolutely non-buckling. The effects of overdriving seem to confine themselves to head and foot. Thus if an impassable obstruction—as a large boulder—is met, some deformation of the foot may occur. Or the head may have its material upset. Any driving subsequent to refusal may thus be expected to disclose itself at the head. The warning is consequently readily

observable. The quality of not buckling is of high value, as then the pile can usually be withdrawn. If severe buckling occurs, the adjacent portion of the steel wall already in place may easily become involved. What lack of real stiffness may occasion is discoverable from the experimental bay of steel sheeting driven at the Hodbarrow Mines and elsewhere described in these articles. The corrugated pile has been put under comparative test with the ordinary channel bar. The two pieces were supported at the ends and loaded in the middle. The result was considerably in favor of the corrugated form. Mr. Wemlinger has made a comparison of the minimum radii of gyration of a corrugated pile and an ordinary I-beam of the same width of 24 inches. The structural shape was 7½ inches deep, as compared with 4 inches for the pile, and weighed four times as much. The thickness of the web was ¾-inch, four times that of the piling. Yet the least radius of gyration of the steel pile was 1.42 inches, while that corresponding to the shape was about 9% smaller.

Driving is promoted too by the small area of the cross-section. Thus to use the case just before us as an illustration, the I-beam having even a less minimum radius of gyration presents four times the surface to the soil to be penetrated. All this would seem to indicate that the disposition of metal in the corrugated pile is of a very superior kind in so far as driving is concerned. That the capability of a sheet pile for driving is no small item may be illustrated by referring again to the experience of the Hodbarrow Mines. It will be remembered that steel sheeting replaced wooden piling because the one could be driven and the other not. If one type of steel piling is more easily driven than another, this fact may enable us to reduce the weight used. In fact, the question of driving may be paramount.

How easy driving may become with corrugated sheeting may be understood from the following instance: A steel pipe line, 42 inches in diameter, was to be laid across an arm of the lake in Cazenovia Park at Buffalo, N. Y. It was desired to use sheet piling for the purpose of following the cofferdam method of construction. But the use of machinery—cableway, derrick or pile-driver—was not desired. Consequently a very slight form of steel piling was selected, and the work of handling and driving accomplished by hand. The corrugated sheeting weighed, in fact, but 7½ pounds per square foot, thus permitting a man to handle lengths of 10 or 15 feet.

In the style known as the *double-lock* there are five full corrugations, three convex upon one face, and two upon the other. Along the summit of the center one of the three a longitudinal locking clip is securely riveted. The sides of this clip envelope the corrugation to one-half its depth. This strip of steel is shorter than the pile, permitting the latter to project a little at either end. Consequently, in driving it is not subject to the direct action of the driving hood or of the immediate reaction of the material being penetrated. When assembling this type of sheeting, the adjacent piles overlap two corrugations each, grooves and corrugations falling into each other. The overlap is sufficient to bring the edges of the adjacent piles well within the interlock. It will thus be seen that if we include the locking clip, a wall of sheeting thus constructed will be everywhere double.

It will be observed that in respect to watertightness this piling should be rather effective. The corrugations intermesh with each other and give a large surface of contact. At any rate, practice seems to warrant confidence in a good joint.

Without the interlocking strip a single pile of the ¼ inch thickness and 20 feet long will weigh about

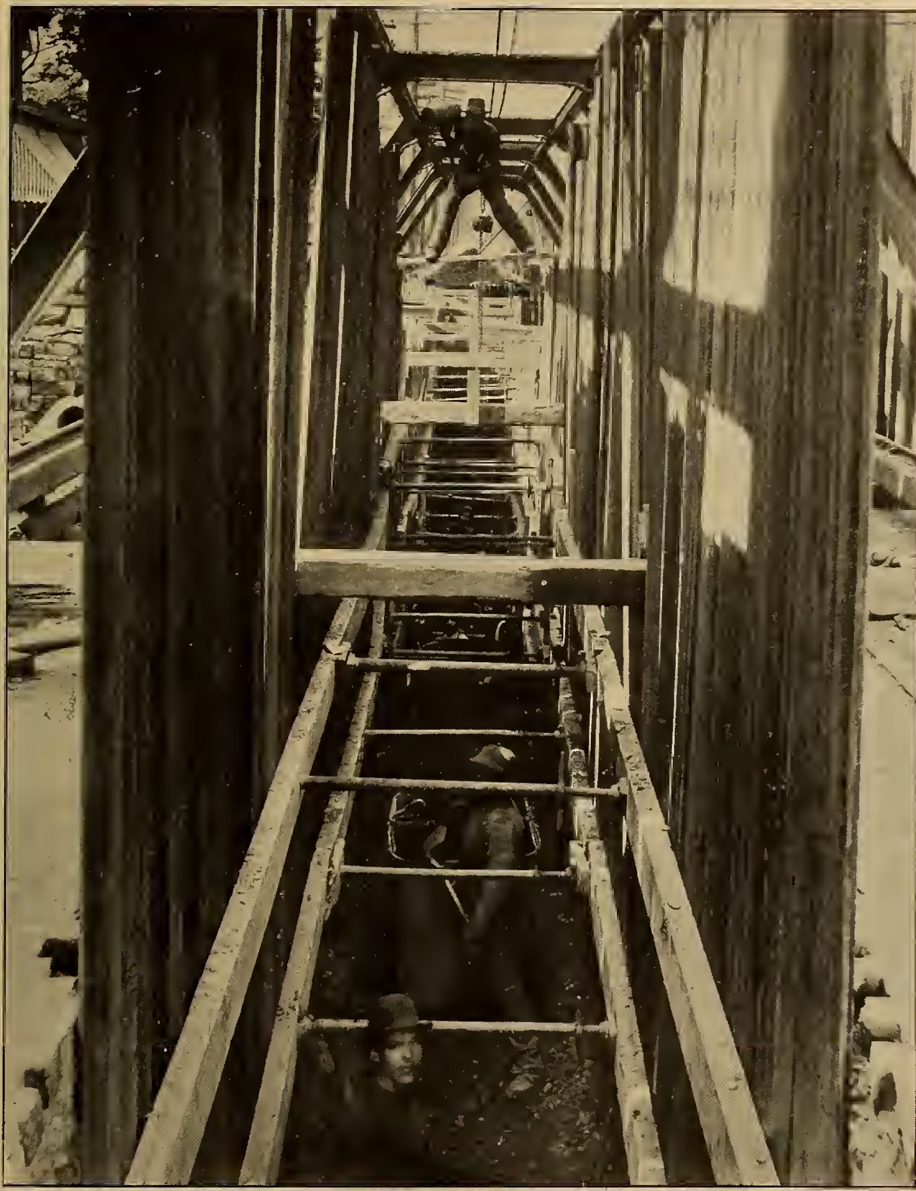


FIG. 19.—SEWER CONSTRUCTION AT WILKES-BARRE, PA., SHOWING ⅛-INCH STEEL SHEETING, 10 TO 15 FEET LONG, DRIVEN BY HAND OR STEAM HAMMER. WEMLINGER STEEL PILING COMPANY, NEW YORK.

570 pounds. With the strip and rivets added, the total weight of such a pile will amount to, say, 140 pounds additional, bringing the whole to 710 pounds. This pile is itself 2 feet wide, and the weight per square foot of surface covered (40 feet square) would be 18 pounds. But when assembled with its companions, it covers in effect merely a width of 14 inches. In consequence of the overlapping arrangement, the weight per square foot, as estimated by the makers, is 30 pounds. The 3-16

FIG. 20.—SEWAGE DISPOSAL PLANT AT OCEAN GROVE, NEW JERSEY

Showing 1/8-inch steel sheeting jetted down in beach sand. Eight feet of the sheeting is unsupported, and the dryness of the adhering sand shows the absence of leakage, although the excavation is below water level.

inch thickness weighs, in place, 23 pounds per square foot, and the 5-16 inch 37 pounds.

Now we can, of course, use as thin sheets as we wish. The piling in place will, however, be double. Instead of thus using excessively thin sheets in order to get when doubled a moderately thin wall for light work, the contractor can obtain a newer type where the sheeting is not doubled. This is the single-lock piling. The difference in construction of the two types will become appar-

ent upon examination of the two sectional views. The overlap with the single-lock covers but little more than a single corrugation at each side of a pile. Two separate clips are used. This results in the wall of sheeting being partly double and partly single. Two of the five corrugations remain uncovered by other metal.

In Fig. 18 we have an example of the use of the Wemlinger Corrugated Sheeting. The old Custom House, fronting on Wall street, in New York City, was acquired by the National City Bank, one of the very foremost financial institutions in the world. This bank remodelled and added to the building and thus constructed one of the most elegant and commodious banking houses to be found anywhere. The piling shown in the figure is of the type shown in the sectional view of the double-lock variety, and was driven to form a retaining wall in connection with the operations of reconstructing this important building. That this piling is of the double-lock type, and not of the single-lock, may be understood by noting that the rows of rivets are alternately on the convexity and in the concavity of the corrugations. That this circumstance distinguishes the one style from the other may be learned by comparing the two sectional views. Returning now to Fig. 18, we may judge somewhat of the lateral strength of this piling when we are told that it is here withstanding the horizontal thrust arising from the pressure of a very heavy masonry wall of about 50 feet in height. There is a hydrostatic head of 10 feet, but just how much of this is effective against the sheeting the writer does not know. The concrete which is partly in place is seen at the bottom. If leakage were occurring it should be taking place along the interlocking strips in view. The incrustations of soil still remaining in just these locations seems to indicate that if any seepage at all has occurred, it must be very slight.

These two types of piling are readily driven and withdrawn, and thus become very suitable for use in temporary construction. And this is especially true of sewer construction. Thus in the Bronx Valley in the vicinity of New York City, a sewer 13 miles in length has recently been under construction. Of course, in a line of this length, conditions would undergo important changes. Now the trench would pass up a hill, now through the woods, now across a stream, and so on. In Fig. 17 we have an inside view of the cofferdam at a point where a stream is being crossed. There were 9 feet of water against the exterior, producing at the bottom a pressure of about 4 pounds per square inch. This was not the double-lock style, but a single-lock variety somewhat similar to that shown in the sectional view. The corrugations were 2 inches deep, and from interlock to interlock was a distance of 12 inches, containing 6 corrugations. The total length of cofferdam was about 100 feet. The form for the bottom of the concrete sewer is in view together with the reinforcement.

In driving the double-lock type, the intermeshing of the corrugations assists in the preservation of the alignment. This would seem to be pretty effective in so far as lateral deviation is concerned. As to front and back departures, the pile already driven is, no doubt, sufficient under all conditions in the one direction. In the other, the two clips—one on each pile— hold the new pile securely. It is scarcely possible that a separation of the old and new piles should take place if the weight is proportionate to the duty. The foregoing remarks apply to the double-lock type. With the single-lock variety the case is somewhat different. But even here the piles are locked in every direction except the vertical. And one should not expect of this light weight style quite the same security against a forward bulging action of the excluded material.

(*To be concluded.*)

Current Topics

THE records which have been recently made in aviation, both as to distance and character of route, are demonstrating that mechanical flight has been taken out of the experimental stage and is entering upon a period of scientific and commercial development. This progress has been made almost entirely because of the increased experience gained in the use of machines already well known. With the exception of the cross-Channel flights of Blériot and De Lesseps, which were made with machines of the monoplane type, the great successes have been effected with biplane machines, similar to those with which the Wright brothers first demonstrated the possibilities of the aeroplane.

During the first half of the present year there has been seen a development in aerial navigation which is little short of marvelous, especially when compared with the slow progress in the early periods of the history of the steam engine, the steamship, the locomotive, and even the automobile. In April Paulhan made his record overland flight from London to Manchester, while in the latter part of May this was followed by the flight of Curtiss from Albany to New York. Within a few days Mr. Rolls doubled the Channel crossing, making a distance of 50 miles within 90 minutes, a feat which had scarcely been accomplished when Hamilton flew from New York to Philadelphia, more than 80 miles, without a stop, returning the same day with but a single stop.

These things show that machines which are much heavier than air can be caused to rise from the ground to altitudes from a few hundred to several thousand feet, be navigated in the face of varying air currents, driven with speed and precision to definite landing places, and controlled with comparative ease and certainty.

In his flight between New York and Philadelphia, Hamilton dropped a number of imitation bombs with fair precision, a significant indication of the military possibilities already attained, and the extent to which adverse criticism has been silenced in this respect may well be worth consideration.

The practical information obtained from these flights, apart from the demonstration of the necessity for individual skill on the part of the aviator, bears principally upon the necessity for improvement of the motor, especially on the score of reliability. It is reported that Hamilton used about eleven gallons of gasoline

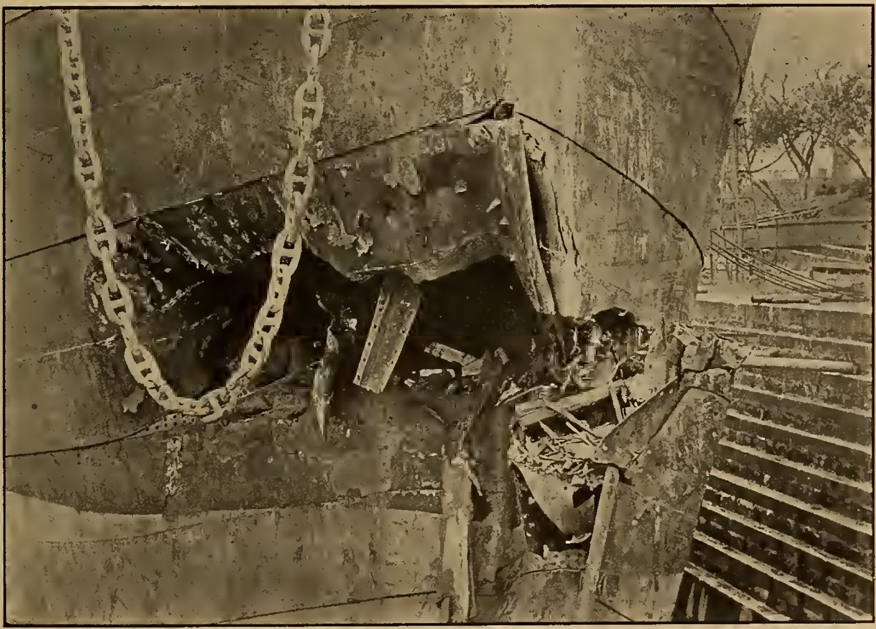
in the flight of about 80 miles between New York and Philadelphia, and that about three gallons of lubricating oil were required. The quality of the latter is most important, and it is stated that the carbonizing of the cylinder lubricant and consequent formation of soot was the cause of the failure of ignition which required the descent on his return trip.

In any case the principal demand at present is not for a lighter motor—the weight has already been sufficiently reduced—and it is *reliability* which must be attained above all things. Given a thoroughly reliable motor, fitted to an aeroplane capable of carrying two or three persons at speeds of 50 miles an hour at heights of more than 1,000 feet, and the practical possibilities of aerial flight may well demand the most serious attention of naval and military authorities, as well as of civilian engineers.

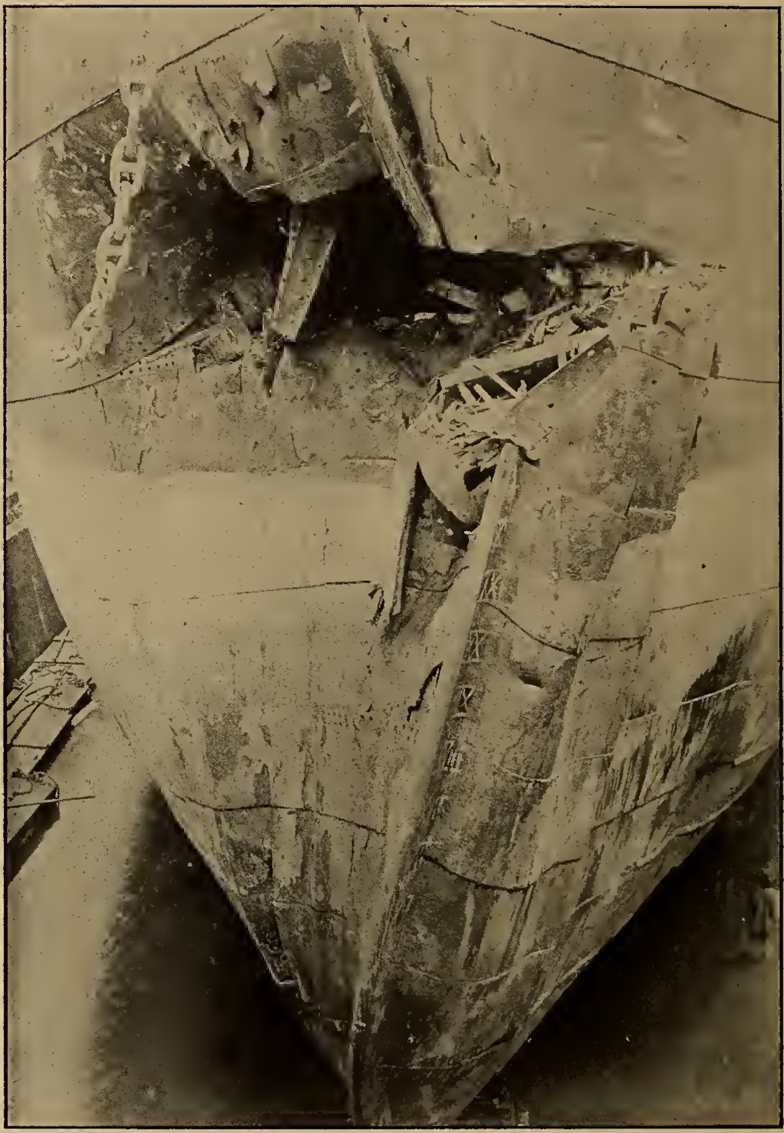
In this connection it is especially interesting to note that nearly all of the recent developments have been elicited as the result of prizes offered by private individuals or by publishers of newspapers, and that such results might well have been attained earlier had governments been willing to devote the comparatively small sums thus expended to this work.

IT has often been said that the real test of construction comes, not in the course of daily use, but in time of emergency, and that the well-designed structure is that which is capable of meeting the unexpected demands which are certain to come sooner or later. Probably this is truest in the case of the construction of a ship. It is when the strain of grounding, or the blow of a collision, arrives, that the honesty and sincerity of the work appears and the soundness of the design is tested.

An interesting example of the resistance which a vessel may encounter is seen in the case of a collision which occurred a few months ago in the early hours of the morning, off Singapore harbour, between the steamer *La Seyne*, of the Messagerie Maritime, and the steamer *Onda*, of



THE BOW OF THE ONDA AFTER COLLISION WITH LA SEYNE



THE TWISTED STEM OF THE ONDA

the British India Steam Navigation Company. The inquiry which followed into the cause of the disaster showed that the blame probably lay with *La Seyne,* but as the lookout man of that vessel was drowned, the cause of the collision was not absolutely certain.

The illustrations show the bow of the steamship *Onda* as she lay in the dry dock in the Tanjong Pagar harbour at Singapore, and these show very clearly the extent of the damage. It is marvelous that the vessel did not sink, and the fact that she remained afloat is a matter of great credit to her builders. The stem of the *Onda* was bent, and her plates dented, torn and shattered in a manner which could be realized only upon examination. The photograph which shows the twisted stem reveals

THE HOLE IN THE CRUSHED BOW OF THE ONDA

also the point at which the bow of *La Seyne* entered.

La Seyne was an old boat, having first seen service at the time of the opening of the Suez Canal, and she was so badly damaged by the collision that she sank in two minutes. As the accident occurred at four o'clock in the morning, the passengers were asleep below, and were drowned like rats in a trap; but it speaks highly for the credit of the officers and crew (Lascars) of the *Onda* that her accident boat was in the water before *La Seyne* sunk. On the British-India Line one boat is always carried swung out on the davits ready for emergency, and it was this accident boat which took the water ready to pick up survivors within such a short time after the collision.

SAMUEL PIERPONT LANGLEY

AN APPRECIATION

IF, as recently as ten years ago, any layman had ventured to assume that mechanical flight would ever reach the commercial stage, or that it would even pass the point where suspicion or ridicule necessarily attached to it, the subject would have been dismissed with a jest. Nevertheless, there was at that time one of the foremost scientists of the world at work upon the solution of the problem, a man who, having attained great eminence as an astronomer and physicist, had reached one of the highest positions open to any scientific man in any country—the secretaryship of the Smithsonian Institution—the head of an establishment founded in America by an Englishman for the "increase and diffusion of knowledge among mankind."

Writing in 1897, Professor S. P. Langley, referring to his researches and experimental work in mechanical flight, said:

"I have, thus far, had only a purely scientific interest in the results of these labours. Perhaps, if it could be foreseen at the outset how much labour there was to be, how much of life would be given to it, and how much care, I might have hesitated to enter upon it at all; and now reward must be looked for, if reward there be, in the knowledge that I have done the best I could in a difficult task, with results which, it may be hoped, will be useful to others. I have brought to a close the portion of the work which seemed to be specially mine—the demonstration of the practicability of mechanical flight—and for the next stage, which is the commercial and practical development of the idea, it is probable that the world may look to others. The world indeed will be supine if it does not realize that a new possibility has come to it, and that the great universal highway overhead is now soon to be opened."

Professor Langley died in 1906, and even before his death the world began to realize that the "great universal highway" was being opened. Within a few years after his departure machines based upon the results of his labours have crossed the Channel, have flown from London to Manchester, from Albany to New York, and from New York to Philadelphia.

The work which, before his efforts, men covered with ridicule is to-day greeted with the acclamation of scientists, statesmen and rulers, while leaders in the world of commerce are striving to command the economic possibilities which are within immediate grasp. Its rewards are already computed by the hundreds of thousands, and its results may change the routes of commerce and the policies of nations.

Surely it is time to express a few words of appreciation for the man who ventured, in the face of opposition and ridicule, to investigate the laws governing the internal work of the wind and of the sustaining power of surfaces; who devoted energy, skill and scientific reputation to the placing of a problem, hitherto despised and scorned, upon a plane commensurate with its true importance, and in a position whence success was surely to be obtained.

The present is not the time to disparage the work of Chanute, of Lilienthal, of the Wrights, of Farman, Blériot, Rolls, Curtiss and Hamilton; but it is the time to remember the magnificent pioneer work of Samuel Pierpont Langley.

FERDINAND, GRAF VON ZEPPELIN

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REINFORCED CONCRETE WORK IN NEW ZEALAND

By B. W. Wilson, B. E.

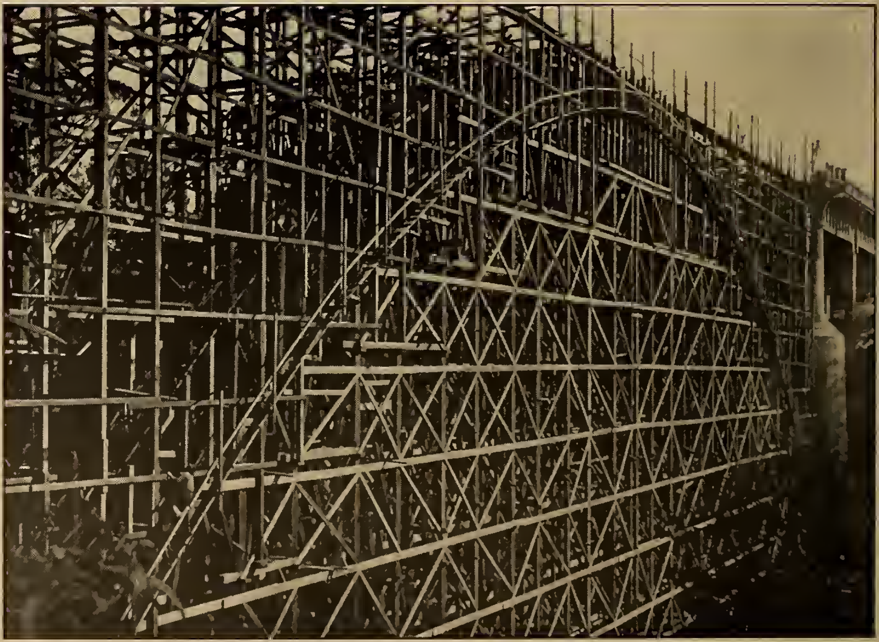
IN few places are the merits of reinforced concrete so fully appreciated as in the North of New Zealand, and in Auckland, the principal city, a large proportion of new construction is being carried out in this material. The supply of Portland cement is abundant from two excellent factories in the vicinity, and the Australasian Ferro-Concrete Company have done a large amount of work here. In the climate possessed by this locality, the warm, damp and highly saline atmosphere renders the corrosion of iron work and the speedy degeneration of painted surfaces serious considerations. For marine work, the energetic depredations of the teredo cause woodwork to disappear in an unusually short time, while the scarcity and comparatively high price of building stone in Auckland have created a strong demand for an efficient substitute. In all these respects ferro-concrete is a satisfactory answer to the conditions imposed by Nature.

The most notable work of this material is the Grafton Bridge, opened in March, 1910, across the Cemetery Gully, situated near the middle of the city. The gully is a wide and deep hollow, effectively separating two populous residential districts, and, what was a most important point, interposing a serious barrier between the Aucklanders and their principal athletic ground, where the chief open-air events of the town are held. A fairly small foot-bridge, low down in the gully, did duty for a number of years. It was then condemned as unsafe, and the ratepayers, by a poll, decided that a high level roadway across the gap, at a cost of about £30,000, was an absolute necessity. Tenders were accordingly called in, for a bridge of 920 feet in length and 36 feet in width between parapets. Two tenders were received, of which the lower was for a steel structure, by the American Bridge Company, costing £28,740. The Ferro-Concrete Company also tendered, specifying a viaduct of reinforced concrete, costing £31,918 and having a central span of 320 feet between abutments, the height being 142 feet above the bottom of the gully.

This enormous span far exceeded any that had hitherto been constructed, and it was only after careful consideration of the arguments for and against the design that this type of bridge was adopted. The great saving in maintenance in the latter case and the much more effect appearance of this design were the features that decided Mr. Bush, the City Council's engineer, in favour of ferro-concrete.

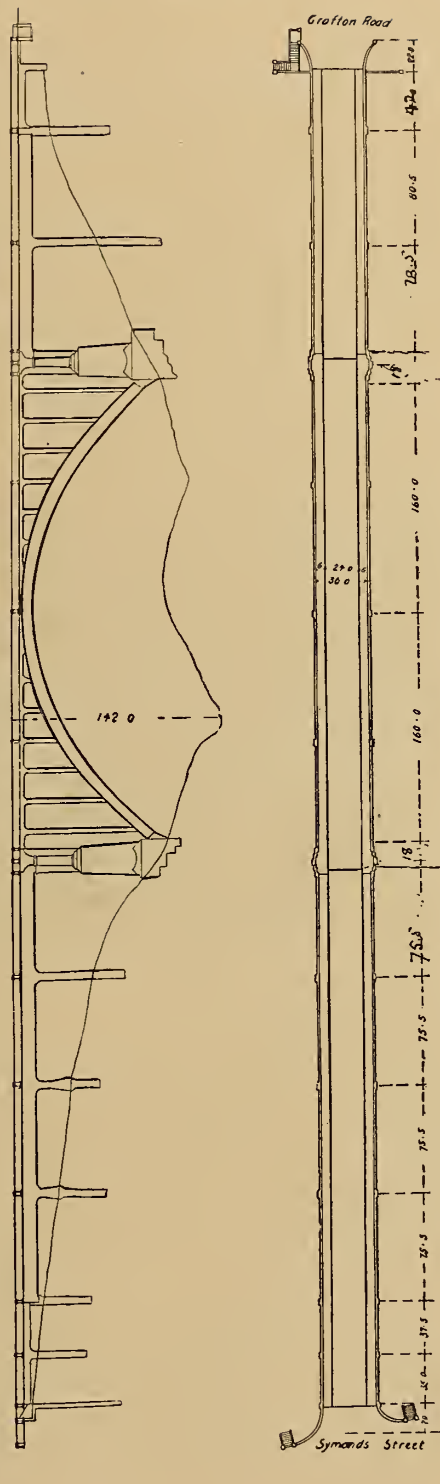
Work was begun in August, 1907

THE GRAFTON BRIDGE, AUCKLAND, NEW ZEALAND, VIEW FROM EASTERN END.



CENTREING OF THE MAIN ARCH OF THE GRAFTON BRIDGE, CONTAINING 400,000 FEET OF TIMBER

THE GRAFTON ARCH FROM BELOW



PLAN AND ELEVATION OF THE GRAFTON BRIDGE, AUCKLAND, NEW ZEALAND

and a little over a year and a half was absorbed in the actual construction. An extra length of about 40 feet was added to the original design, on account of negotiations for closing a blind road ending unsatisfactorily.

The arrangement of the various component spans is as follows, starting from the western, or city end:

One span of 35 feet;
One span of 37.5 feet;
Four spans of 75.5 feet each;
One span of 320 feet, between piers of 18 feet at the top;
One span of 78.5 feet;
One span of 80.5 feet;
One span of 42 feet.

The approach spans presented no great difficulty and were completed first with the two main piers at their terminations. Straight girders are used throughout, of solid design in the case of the three shorter ones, and of open panel in that of the remainder. The big piers take the form of hollow pillars, about 100 feet in height, with walls from 12 inches to 8 inches in thickness. One wall

of each is cut away at the base to accommodate the main abutments. These contain 720 cubic yards of concrete, resting on the rock of mudstone underlying the whole town and carry the cast-steel hinges which support the main arch.

The great central span is naturally the most interesting portion of the whole achievement. It is constructed in two equal parts, hinged in the middle, and is therefore what is technically known as a "three-hinge arch." The chief members are the two parallel ribs, which range from 6 feet by 4 ft. 2 in. at the abutments to a maximum of 9 ft. 9 in. by 4 ft. 1 in., diminishing to 5 ft. by 4 ft. at the central hinge. Connecting the ribs laterally are ties 8 ft. 4 in. by 1 ft. 8 in., spaced at 21 ft. horizontal centres.

Rising from each half-rib are seven piers of T section, the cross of the T being 3 ft. by 6 in. and the remaining portion 2 ft. 6 in. by 10 in. Transverse girders rest upon these, dimensioned 3 ft. 7 ins. by 10 ins., and there are 5 secondary beams 1 ft. 8 ins. by 10 ins., parallel with the length of the bridge, supporting the deck, of 6 in. ferro-concrete. The footpaths are carried by cantilevers projecting from each transverse beam, carrying 5.5 ins. of decking. Cross-bracing connects the three longest piers in each section, taking the form of T-beams, spaced about 30 ft. apart.

THE MAIN SPAN OF THE GRAFTON BRIDGE, AUCKLAND

To hold the liquid material of the main arch while it was setting, a maze of timbering was erected, consisting of 400,000 superficial feet of West Australian jarrah and Oregon pine. A view of the work before pouring was begun is given, and its huge size may be gathered by comparison with the workmen perched upon the scaffolding. The height of the moulds was adjusted most accurately by 160 bottle-jacks, which performed their work much more effectively than the sand-boxes more generally employed. Wedges were also used to supplement these, and also to facilitate the removal of the

OLD AND NEW STYLE WHARF CONSTRUCTION AT BIRKENHEAD, AUCKLAND HARBOUR, NEW ZEALAND

REINFORCED CONCRETE WORK IN AUCKLAND HARBOUR

WORK OF THE TEREDO ON TIMBER PILES IN AUCKLAND HARBOUR

timbering when its duty was accomplished. So carefully was this complicated temporary structure erected, that the dead load of 3600 tons was accurately and rigidly supported until capable of bearing its own weight.

The open panel girders of the approach spans are 9 ft. deep and 15 ins. wide. There are three parallel girders in the width of the bridge, supporting transverse secondary beams of 6 ins. in width and 2 ft. 6 ins. in depth at the middle girder, tapering to 1 ft. 6 ins. at the outer girders. These are continued to form cantilevers for bearing the footpaths. The piers are each composed of two solid vertical pillars 5 ft. by 4 ft., connected at the summit by a deep transverse beam. Ordinary solid girders 3 ft. 9 ins. by 15 ins. are used in the three short spans.

Special means had to be adopted to cope with the expansion of so great a length due to variations of temperature. In the main span the hinges permit of expansion without displacement of the abutments. On the city end there is a long stretch of four spans constructed in one continuous length. The extremities of this are supported on steel plates and are thus free to slide. It is anchored, however, to the three intermediate piers, as the middle one will obviously remain stationary under all ordinary circumstances, while the other two possess sufficient elasticity to bend the small amount required without possibility of fracture. The same method is adopted in the case of the two longer spans at the eastern end.

Reinforced concrete parapets, 4 ft. 9 ins. high, flank the top of the bridge, and 26 cast-iron lamp-posts rise from these, each containing a 25 candle-power metallic filament electric lamp, operated by an automatic time switch. The roadway is paved with Neuchatel asphalt to a thickness of 1½ inches.

The final act was the official testing of the completed fabric. It was considered that the carting of heavy material over the approach spans had sufficiently proved their stability and

no further trial was demanded of them. With the central span, a dead weight of 292 tons of road-metal, equal to 113.5 pounds per square foot, was imposed on half the arch, taking about three days to place in position. This caused a maximum deflection of only one-eighth of an inch during the whole time. After this load had been removed, two road rollers, of a joint weight of 32 tons, were driven across and back, causing a maximum deflection of one-twelfth-inch in the main arch and of one-fifteenth-inch in the approaches. These results may be regarded as very satisfactory indeed and form a worthy termination to a work which reflects great credit upon all concerned. Mr. R. Moore, of the Ferro-Concrete Company, was the designer.

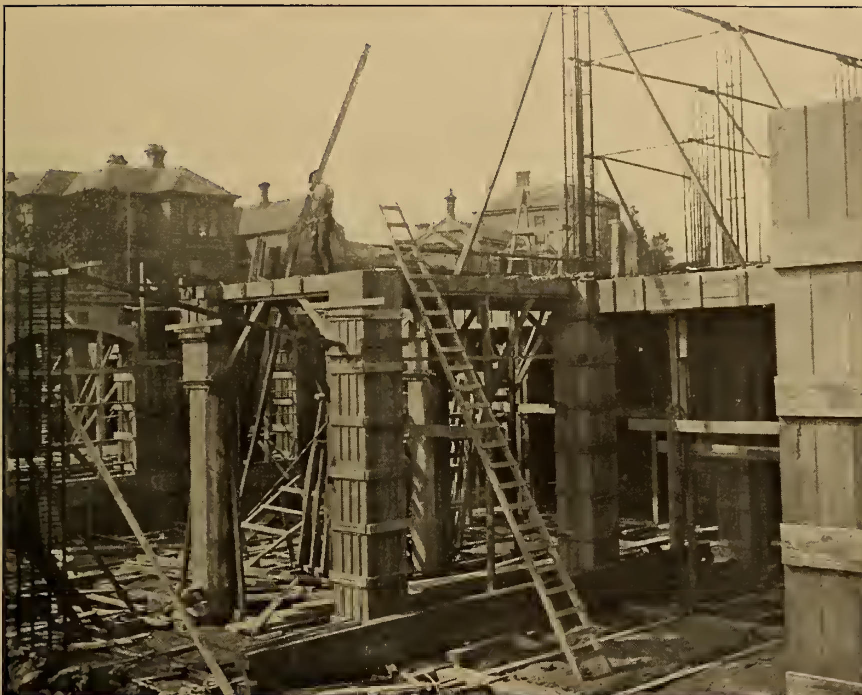
Reference has been made to the ravages of the teredo in Auckland harbour. It is little short of astonishing to note the havoc wrought by this insignificant-looking pest in the short space of seven or eight years, wooden piles, 12 inches square, being almost eaten through in that time. The illustration shows some, indeed, which have been quite severed and which seriously endanger the safety of the wharf they were intended to support. Even the Australian jarrah and the various kinds of eucalyptus, which have given good results in their native country, are quickly eaten through by the Auckland variety of worm. The New Zealand totara and the Australian turpentine are the timbers least attacked, but even these are far from immune. Piles of one local wood, the kahikatea, or "white pine," have been entirely destroyed in three months' time. To overcome this great difficulty, the Harbour Board Engineer decided in 1903 to recommend reinforced concrete construction for new work. At about the same time a large extension of the wharf accomodation was planned and a comprehensive scheme adopted, including retaining walls and also reclamation works. all of which are being constructed of plain and reinforced concrete.

A COMPARISON OF NEW AND OLD PILING

This enterprising policy was not carried into effect, as enterprise rarely is, without considerable opposition, in this case from those who failed to grasp the principle of the new material and were therefore not in a position to realise its great advantages. A most effective test was arranged at the outset, by the engineer, to demonstrate the enormous strength imparted to concrete by the incorporation of a small amount of metallic reinforcement. Two arches of exactly similar size were constructed, one of simple concrete and one strengthened with three half-inch iron rods along the tension side. The dimensions of these arches were 12 ins. by 3 ins., the span was 19 ft. and the rise 3 ft., and they were

THE FERRY WHARF, AUCKLAND HARBOUR, WITH OLD QUEEN'S WHARF AT THE RIGHT

TEMPORARY APPROACH DURING WHARF CONSTRUCTION, AUCKLAND HARBOUR



REINFORCED CONCRETE CONSTRUCTION WORK ON THE NEW TECHNICAL SCHOOL, AUCKLAND, NEW ZEALAND

THE TECHNICAL SCHOOL, AUCKLAND; CONCRETE FOUNDATION WORK

TEST OF REINFORCED CONCRETE ARCH FOR AUCKLAND HARBOUR

made of four parts of fine, shingly sand to one of locally made cement. A man weighing 196 pounds was directed to stand, without jumping, on the former and it broke in eleven clean cracks as a result. The second arch was loaded, as shown in the figure, with 19.5 tons of pig iron and sustained this heavy load for three hours, collapsing gently when being unloaded, the concrete being powdered. The value of the reinforcement could scarcely have been more graphically demonstrated.

The first reinforced concrete work in Auckland harbour was the construction of a breastwork to replace one of timber that had already been renewed no less than three times. Other work of this description is being carried out in several parts of the harbour, notably at the Freeman's Bay reclamation. In the former case, land was reclaimed for large workshops and to support a set of 156 ft. shear-legs, behind reinforced concrete retaining walls. A boiler, loaded to 120 tons, was lowered, on the erection of the legs, upon the deck of the concrete wharf, causing a deflection of only one-eighth inch. At Freeman's Bay, an area of 67 acres has been enclosed by means of a plain concrete wall and a reinforced concrete quay, and the shallow water is being converted into valuable property by filling in spoil from the dredges and from the land.

It is in the main port wharves, however, that the chief work is being done. Here the old Railway Wharf, on the eastern side, has been replaced by a most substantial structure of a width of 240 ft. and a length of about 1500 ft. Upon this, standing back 30 ft. from either sea-front, are two long sheds, built wholly of steel and iron, 60 feet wide and separated by a roadway of similar width. Modern electric cranes are at present being installed. That known as the Queen's Wharf, affording the chief means of access for passenger and general cargo boats, is now undergoing similar treatment. Much of the total length of 1200 feet has been completed to a width of 280 ft., and two double-story sheds

BUILDING THE NEW QUEEN'S WHARF, AUCKLAND HARBOUR

PIERS FOR THE QUEEN'S WHARF, AUCKLAND HARBOUR, NEW ZEALAND

are being erected of a width of 80 ft. Near this wharf are smaller offshoots, provided with facilities foi the speedy arrival and departure of the ferry steamers which play so important a part in the transit between the city and its numerous harbour-suburbs. When these are completed, further work on the same considerable scale will be immediately proceeded with.

With regard to the use of reinforced concrete for buildings, two instances may be given. One is that of the new post office now being erected, the foundations ior which include 280 ferro-concrete piles, ranging from 49 ft. to 29 ft in length, driven down to the mudstone. This kind of foundation is finding increasing favour and was also adopted in the case of the new five-story Technical School. Here, however, the rest of the building is to be of the same material. Other examples might be quoted of the use of ferro-concrete, but enough has been said to show that it is filling a decided want in the southern hemisphere as well as elsewhere.

INDUSTRIAL BETTERMENT

By H. F. J. Porter

GENERAL ADMINISTRATION. SELECTION, EDUCATION AND STIMULATION OF WORKMEN; THEIR HEALTH, HOUSING, SOCIETY AND PROTECTION.*

BEFORE entering upon a general discussion of the various methods in business administration which relate to the treatment of the working organization, I desire to touch upon the phrase "Industrial Betterment," which, in many minds, is confined solely to matters affecting the human element in that organization, physically, morally and mentally.

Inasmuch as the human element is so intimately related to everything which takes place in a business or industrial enterprise, such an understanding is, to a large extent, correct; but I desire to make it plain that anything or everything which tends to improve business or industrial conditions comes under the category of Industrial Betterment.

Reverting, for a moment, to the recent past to seek the origin of the phrase referred to, we find that during the last few years of the nineteenth century, when industry was making enormous strides and competition was becoming very keen, every innovation in manufacturing methods was sedulously sought out and carefully scrutinized for the purpose of observing its effect upon the establishment to which it was applied.

In this search for improved methods progressive manufacturers had their attention directed to certain features which German manufacturers, at the instigation of and aided by a paternalistic government, had adopted in a national effort to improve the health, social condition and intellectual standing of the working classes. These features comprised well constructed and comfortable factory buildings, with good light and ventilation, sanitary toilet facilities, wash rooms with hot and cold water, soap and towels, coat rooms with clothes lockers and drying apparatus, rest rooms, lunch rooms with wholesome food at cost, libraries, safety appliances on the machinery, emergency hospitals with skilled attendants, compensation for accidents, beneficial organizations, furnishing insurance in case of sickness and death, long service and old age pensions, and many other innovations extending to the housing, environment and recreation of the employee outside of working hours. These features had obtained the name of *Wohlfahrts Einrichtungen*, or "Welfare Institutions," which, when their purpose was considered, was eminently appropriate.

A careful investigation of these features revealed the fact, however, that not only were they of great benefit to the working people themselves, but that they were productive of increased prosperity to the establishments which had introduced them.

It did not take long to grasp the rationale of this result, viz: that it was the improved workman who was accountable for the more efficient workmanship, and that it was the totality of the effect of this fundamental, economic and educational movement which was bringing Germany to the front in international trade competition. Action promptly followed the determination to adopt

* A lecture delivered before the Graduate School of Business Administration, Harvard University, Cambridge, Mass.

such of these features as were deemed applicable to our establishments here, and the appellation of Industrial Betterment, which was intended to apply to the general improvement in industry which came about simultaneously with their introduction, seemed to refer specifically to these features, was largely so interpreted, and in many minds is still associated solely with them. Later, in an effort to give them a more distinctive title, the term "Welfare Work," an incorrect and misleading translation of the German appellation, was adopted in some of the larger establishments; but this turned out to be very inappropriate and most unfortunate in its effect, as it proved to be obnoxious to working men and women as bearing an implication that they belonged to an inferior class which needed an uplift by the employer, and anything savoring of paternalism or charity was resented by the self-respecting employee.

There was also a hypocritical attitude on the part of the employer implied in the assumption that he was instituting improvements for the welfare of his employees, and as in each case this "Welfare Work" had been installed solely for the benefit of the business, this implication was misleading, tending to place both employer and employee in false and unnatural relations to each other and increasing the class consciousness which already existed.

The real estate owner who erects a modern office building on the site of an old one and makes it fireproof, with plenty of light, heat, ventilation, sanitary toilet accommodations and attractive embellishments, does these things to keep abreast of the times, to meet the competition of the day, and to draw a better-paying class of tenants. The employer who erects a modern factory building, making it fireproof, with plenty of light, heat, ventilation, sanitary toilet accommodations and attractive embellishments, also does these things to keep abreast of the times, to meet the competition of the day, and to draw a better class of workmen, who, by their higher efficiency, will make his business pay better. There is not in the mind of either real estate owner or the employer of labour the least idea that he is doing these things for the welfare of his tenants on the one hand, or of his employees on the other. In each case he has done them because it has been found that such improvements are in the line of present-day progress, that they pay an increased interest on the investment, and, therefore, in each case it is initially for the welfare of the projector of the improvements that they were performed; and because these features have a reflex beneficial effect upon those who choose to take advantage of them neither projector should pose as a philanthropist and patronize the beneficiaries, and feel hurt because they apparently do not realize, or, at all events, do not express their obligations to him for such benefactions.

It is important that warning should be given regarding misleading interpretations of these terms at the outset, since there are instances in which these features have been introduced under the term "Welfare Work" and have actually failed of their purpose on that account.

In the next place, I wish to emphasize particularly the fact that no business or industrial enterprise can afford to do anything which does not bear directly upon securing the increased efficiency of its mechanical processes and working organization. Anything beyond this as applied to the human element savors of charity, which is outside of the province of a business enterprise, and is bound to react unfavourably upon its success. But anything which will increase efficiency it will be perfectly proper to do, provided care is taken that it is done in the right way. As everything that comes under the head of "Welfare Work" tends towards efficiency, it would be more rational and straightforward to call it all

"efficiency work," which would describe it perfectly and be acceptable to both employer and employee.

In this connection, however, we must realize that our standards of living are steadily rising. Certain needs which are imperative to the individual now were not so some time ago, or are so in one place and not in another. These are brought about by advance in civilization and social or industrial competition, and vary according to location and environment of the individual. Problems have been developed by the growth of shops, from the small one where the owner was a mechanic and knew all of his men by name, and was on friendly terms with each of them, to the larger one with its enormous aggregations of working forces running up to thousands, where the head of the concern never comes in contact with any of his workmen.

The study of economics in educational institutions has developed researches into the means for increasing national efficiency and for the conservation of national resources, and we are learning that the waste of labour and material in industrial enterprises everywhere is enormous and unnecessary. Efforts are, therefore, being made in all directions towards its prevention as well as cure. Dr. Eliot has said, regarding the way which human beings are being used up in the trades: "Every blunted intellect, every maimed or diseased body, is a direct tax upon the people, through the necessity for maintaining hospitals and invalid homes at the public expense. We now know that the most effective labour, and cheapest in proportion to its product, is found where the labouring classes live comfortably, are well housed and fed, develop their intelligence and widen their prospects. The cheapest labour is no longer considered the most profitable."

As a result of this change in our economic standards, political and social reformers in our Legislatures are framing laws making it a crime for men or corporations to exploit for their own selfish ends the time and effort of their workers, especially children, regardless of the result upon them, and the courts are enforcing these laws against those who have not attained to these higher standards, requiring their recognition or the payment of a penalty. Manufacturers are being told that they should protect and insure their employees from accident and charge the cost to the product to be paid by the consumer; then only those who choose to buy the goods pay the tax.

So that now the State, when it grants to a man or a corporation a charter with the privilege to do business or to operate a factory, realizing that the conditions and tendencies affecting the employment of people engaged in the enterprise have an intimate relation to the social problems with which the State has to deal, insists that the business or factory shall conserve rather than become a menace to the interests of the people with whom it has transactions and of the community in which it is located.

We must also appreciate that our ethical and economic standards are advancing. A great change has come about in the relations between men generally, as compared to those which existed twenty-five or thirty years ago. The broader spirit of the times inculcates the doctrine that all men are brothers. The "square deal" and "fair play" are common phrases in the business vocabulary. Giving consideration to the other man's point of view is a practical demonstration of the Golden Rule.

But every concern has certain needs and conditions which must be met in an individual way, irrespective of how some other concern makes the attempt. We must, therefore, be guarded in advocating special methods for one factory merely because they have been successful in another, and careful in our criticism concerning those who have adopted certain methods in their efforts at industrial betterment of this type merely be-

cause we know that other concerns adopted them inadvisedly and found them detrimental to their business. This would seem to be self-evident; and yet it is seldom understood.

A short time ago I was visited by a manufacturer who told me that he desired to improve conditions in his plant, and as he had never done anything in the nature of what he called "Welfare Work" for his employees, he felt that he would like me to tell him what features would be best to introduce. He told me that after he had come to his decision to do something of this kind, he had written to several of the large representative concerns of the country asking what they had done in this direction, and he had their replies to show me.

To his surprise I told him that I did not care to see their letters, as they had no bearing on his case, and that he was acting like a man who felt he had something the matter with him physically and, without diagnosing his own case, had asked various friends what medicines they had been taking for their ailments, which were probably of an entirely different nature. I told him the only way for him to proceed would be to study his own needs, and when he had found out what they were, to meet them in the most effective manner. And this I then found was what he, on account of his method, or rather lack of method of management, did not know how to do.

Now, let us see what is the best way to bring about industrial betterment to meet the requirements of the working organization. In the first place, it is evident, owing to the varied conditions existing in different establishments, that in each case they must be studied in order to be understood, and that this study demands the application of the scientific method of investigation which, although of recent origin, has now completely replaced the empiricism of the past, if we expect to trace the relationship between cause and effect, between acts and their consequences. To secure this information and to use it effectively requires intelligence of a very high type to begin with, in conjunction with a course of instruction in the art of management. By these means only a knowledge of competent managership can be secured.

Competent managership is what has to be learned from those who, by actual experience in the field of industry, have proven to be successful managers, and by this I do not mean merely successful financial management in the interest of the enterprise, but that broader successful management which takes into consideration the employee, the community, the State and the Nation.

In the first place, management has largely to do with the understanding of human nature, and this element of man does not vary much, whether we have under consideration a few or a large number of people. The same principles apply whether we are concerned with the management of a small group, such as is included in an industrial enterprise, or a larger one as embodied in an industrial town or a city, State or a Nation.

There are many industrial enterprises employing in a single plant from 5,000 to 15,000 men and women who spend there the greater number of their waking hours. Each of these plants constitutes a good-sized town.

In all of these the same social laws prevail. These laws are man-made and then enforcement is carried out by man. Civilization advances, customs change, and as fast as laws enacted to meet certain conditions prove to be ineffective, they have to be changed to meet the exigencies of the new situation.

It is by the study of history and the analysis of action and reaction that we are able to note tendencies, and tendencies are prophetic, inasmuch as they indicate the direction in which we are going and so give us foresight to determine whether we

shall continue our course or change it.

Looking back over the history of nations, and studying the kinds of government which they have adopted, and observing their effects upon the people, we note that the tendency has been to change from absolute monarchy or one-man control, first to oligarchy, or control by the few, and finally towards representative government, i. e., government by the people themselves, or self-government.

In both of the former the service of the many was exploited for the benefit of the ruling element, while in the latter every man has a voice in determining what shall be done to him. Favoritism to the few in the former is replaced by equal opportunity for all in the latter.

Just so in the domain of industry, the factory organization self-governed, when properly directed by competent management, has been proven to be the best managed organization. But some employers say they would not trust their employees so far as to enlist their co-operation in a representative system of management. These are the employers who are having the most trouble with their men because the latter in turn do not trust them, and when there is mutual distrust there can be no harmony or co-operation. Some employers say they cannot yield their authority to their organization or their responsibility will cease. This would be true if they yielded their authority, but they do so no more than a man yields the use of his legs when he uses a carriage. On the contrary, he uses both as vehicles to reach his destination.

These employers, ruling as absolute monarchs over their little realms, are relics of feudalism. They are so enamored of their self-assumed right to rule that they assert it arbitrarily. Occasionally, when they are exceptionally overbearing and arouse the resentment of their subjects, they plead for co-operation, but expect the latter to do all the co-operating, and when one workman who, on account of his higher capabilities as a leader, is put forward by his fellows to present their grievances, he is at once selected as an agitator or disturbing element, and discharged. This man's inherent superior qualifications, which are recognized by his fellow workmen, are thus repudiated by the management. Just as by this process Russia has lost her ablest reformers, so are employers daily losing their most competent workmen.

Again, Dr. Eliot says, in his monograph on "Education for Efficiency": "The faculty for discerning and using conspicuous merit in other people, distinguishes the most successful rulers, administrators and men of business." Too many men, however, dislike or fear opposition, and endeavor arbitrarily to dispense with it. But wherever there are strong minds, there is bound to be diversity of opinion, and it is this which, when given freedom of expression, brings about new ideas and advance and progress. It requires resistance to develop energy; autocratic suppression of it as under absolute monarchic rule, engenders stagnation for a while, till fermentation develops and then comes the inevitable clearing up process, which is apt to be expensive.

This sort of absolute monarchical management of industrial establishments is an anachronism in the twentieth century. It is a condition of unstable equilibrium in countries where men are supposed to be free, but are by no means so during their waking hours; where thousands of these little feudal domains exist, with millions of serfs employed in them, all dominated by fear and each utterly helpless even to express his many grievances. It is not surprising from our studies of history and our knowledge of human nature, that workmen who are daily being reminded of their right to a liberty which they do not possess, have organized and are fighting through their unions to obtain that liberty.

First formed for defense, these

unions grew large and powerful, and in the hands of the self-exploiting demagogue have frequently been a menace to individual industries, and a source of much suffering to their members, and expense to the public. This labor movement, if intelligently directed, might be of great benefit to all concerned; but, as Henry George, Jr., writes on "The Dangers of Unionism," "large, unincorporated bodies of this kind, wielding great powers without responsibility, are seldom controlled by men of sound judgment and integrity. Where men get power for which they do not have to account, they become corrupted by it, and they abuse it, or else, resisting temptation and striving to use their power well, they are swept aside by the crafty and unscrupulous. Human nature remaining what it is this must be the rule."

And the same statement applies to the average employer when vested with the supreme control of his employees.

The industrial betterment theories of the labor unions are in the main praiseworthy, and the results which they have permanently attained are undoubtedly meritorious. What they have secured, however, is far less than they have demanded and could have attained with a moiety of the effort expended. Their aggresive methods are as objectionable as the tyrannical methods of some employers, and a working organization which is subjected to the disturbing influence of both is in a sad plight, and in no position to render efficient service. Fear is still the medium used by many to compel subservience, as it was in the dark ages, whereas, in these enlightened days it is known that only by the absence of fear and its replacement by confidence can satisfactory results be obtained. If the unions would adopt an educational propaganda to induce employers to accept democratic ideas, instead of endeavoring to enforce their ideas by militant methods, they would accomplish their ends more rapidly and more effectively than they are now doing. But the unions will eventually drive industry to adopt democratic methods by a negative process, just as the evils of standing armies will compel nations to arbitrate their differences, or as the boss and the machine have driven municipalities to adopt government by commission. Thus will the unions accomplish their purpose, but by a method entirely unpremeditated and undesired by them on account of its disastrous reactive effect upon them; for when an industrial establishment is controlled by a representative management its members are in so much better condition than when dominated by a union that they are only too glad to drop the latter and be independent.

The tendency on the part of the governed under an absolute rule is to oppose the existing order of things, which they cannot understand and which they feel does not favor their interests, but exists for the purpose of conserving the interests of those who have brought it about. The tendency of representative government is to make everybody concerned do his part toward bettering the conditions which affect him and his fellows.

These two methods of government, therefore, draw their inspiration from opposite sources, ignorance and knowledge. One comes from suppression of information, the other from publicity. One encourages revolution, the other evolution. Wrong thinking develops one, right thinking the other. No man need be feared who thinks right. Get men to think right and the rest will take care of itself. But right thinking requires freedom of personal initiative, or compulsion from within rather than from without. One through restraint discourages the establishment of enlightened public opinion, the other encourages it, and it has been found that where public opinion can be established on a basis of intelligence, there is no more potent element for safe progress, and the best

way to establish public opinion is by a policy of publicity.

James Bryce, in his "American Commonwealth," says:

"Towering over presidents and State governors, over Congress and State legislatures, over conventions and the vast machinery of party, public opinion stands out in the United States as the great source of power, the master of servants who tremble before it. . . .It grows up not in Congress, not in State legislatures, not in those great conventions which frame platforms and choose candidates, but at large among people. It is expressed in voices everywhere. It rules as a pervading and impalpable power like the ether which passes through all things. It binds all the parts of the complicated system together and gives them whatever unity of aim and action they possess."

It would seem to be necessary, then, in order to secure substantial betterment in the domain of industry, that the basic principles of representative government should become dominant in it, and it is interesting to note in exemplification of this statement that whenever these principles have been scientifically applied there has been an immediate and remarkable improvement in conditions.

Theory has proclaimed their practicability. Frequent trial has demonstrated it.

What concerns us now, therefore, is the means by which these principles can be applied to an industrial organization. How can they be instituted in a factory, and how do they accomplish what the ordinary form of shop government constructed on the monarchical plan has signally failed to secure in the past, i. e., industrial peace, without which no shop can settle down to enthusiastic and effective work.

In the first place, the system of management must be a representative one, so constituted that the working forces have a recognized channel whereby the opportunity is extended of expressing their needs. This expression must be encouraged and consideration given to it by a permanently organized board or committee, composed of a representation of the working forces. This board must be inspired and authorized to act in accordance with its best judgment, for the ultimate betterment of the business as a whole. For this reason, the more intelligent its personnel and the better informed it is, regarding the bearing of general matters on the business, from the standpoint of economics, the better will be the results obtained. It must, as much as possible, be free to reach its decisions unhampered by outside influences. For this reason the shop must be in every sense an open one, free from entanglements with labor unions.

The ways of adopting representative methods of control in industrial organizations vary according to the conditions existing in each one of them; but all of them must embody some means of co-operation between management and working force, which can best be accomplished through an elected board composed of representatives from these two elements.

Some concerns, like the Pennsylvania Railroad Company, the United States Steel Corporation and the National Biscuit Company, reserve a certain amount of stock at a reasonable cost, and encourage their employees to buy it, and thus become part owners in the enterprise, with a right to vote for representation on the Board of Directors. Others, like the N. O. Nelson Co., of St. Louis, extend their profit-sharing system so as to include their customers. These are examples of the direction in which those who are willing to break away from the beaten path are moving. Between the two extremes referred to are many who, like the William Filene Son's Co., of Boston, form a permanent shop committee, elected by the employees, and this committee has certain privileges of recommendation regarding the betterment of shop conditions, of improve-

ment in methods of manufacture, and design of product, to a committee appointed by the management, composed of the heads of departments.

A system of this kind closely resembles the American democratic form of State and National government with its elected lower house, its appointed Senate, and at the head the Governor or President with his cabinet.

In this instance the cabinet consists of the officers of the company, viz., the treasurer, who has charge of the receipts and disbursements of money; the secretary, or general sales manager, who obtains the business; the superintendent of manufacture, who has charge of the conversion of the customer's orders into finished product, and the controller, who supervises the accounting or cost of the transformation of working capital into bills receivable. These four officers must develop departments which are entirely separate and distinct from each other, but which must be so harnessed and driven that they will pull together in parallel with proper team work.

When some means of participating in the financial vicissitudes of the business is added to a representative system of this kind, the interests of management and employee become identical; the workmen work *with* rather than *for* the management, these two elements pull together, and the best conditions exist for industrial betterment.

Having constructed the framework of the organization according to the plan outlined, it will be necessary to install administrative machinery of a type which will be in sympathy witn those forces which are most effective in developing the latent efficiency of the human element in the organization as a whole, to its fullest extent.

The representative system must be further developed according to the requirements of each establishment, but a very satisfactory means of obtaining the close co-operation of the individual operative with the management is by the development of a definite channel by which he can express his ideas and needs to the committees.

These expressions are made in the shape of signed suggestions, which are passed upon first by the Works Committee, composed of representatives of the working organization, then by the Board of Foremen, and finally are disposed of by the Manager, or whoever is in active charge of the business. Every suggestion which is adopted is paid for.

By accepting no anonymous suggestions, and by giving full publicity to the actions of the committees, the dignity of character of the system is maintained, and it becomes one of the most fruitful elements of Industrial Betterment so far devised. It must be recognized, however, as a subordinate but important part of a representative system of management, and not an entity in itself which can be incorporated into a business organization as ordinarily constituted. It is a plant which thrives and brings forth abundant fruit in proper soil, and right environment, but is blighted and soon dies in captivity. I have seen attempts made to install suggestion systems by managers who did not believe in representative control methods, and they have been complete failures.

Once there is established in the minds of the working organization a feeling of confidence that, instead of exploitation, methods of co-operation have been promulgated by the management an esprit de corps is developed which is far more effective for shop discipline and efficiency than all the fear which can be engendered by strict supervision. This sentiment once established, all the rest comes, and if it is accompanied by efficient management it comes so quickly as to surprise everybody by the results.

Now, as to some of the details of Industrial Betterment, let us consider:

1. THE SELECTION OF WORKMEN.

In this connection it must be borne in mind that the characteristics of an

efficient workman are, first, good health, without which he cannot be regular in attendance, permanent in service or capable of giving a normal amount of strength physically or mentally to his duties when at work. Second, he must be of high moral quality or his habits outside of working hours will disqualify him when at work, and, third, he must be of good mental caliber and have high manual skill in order to think and work right.

Every industrial establishment, managed according to modern ideas, establishes a beneficial society among its workmen and helps it financially. This society provides for the workman during periods of sickness and assists the family at his death. One of the duties of the physician whose services are controlled by this society should be to pass upon each employee before he is accepted as a member of the organization. He should be one of the staff of the employment bureau, which should include also one or more members of the working organization. The only way the latter can develop and maintain an esprit de corps is by letting it have something to say about its personnel.

2. THE STIMULATION OF THE WORKMEN.

The environment of the workmen in the factory, his hours of work, his wages and his prospects of advancement, must all be so attractive as to cause him to strive to do his best in order to hold his position.

Where such conditions exist there is always a waiting list of applicants, and there is no better stimulant to exertion than the knowledge that if one does his duty he is fully protected, but that if he neglects it he discharges himself and there is a man ready to take his place on short notice.

But human nature needs encouragement. It responds better to coaxing than to prodding. Men can easily be led and they will then be imbued with a better spirit than when they are being driven. In the first case they move by their voluntary will, in the second case they move by the initiative of some one else's will, which means against their will, and then their resentment is aroused. Progressive managers have installed various means of encouraging men to work, finding that force does not bring about desired results. Bonus systems of payment are more conducive to exertion than fines or docking wages. The payment of a premium on punctuality and regularity of attendance will get the individual machines started promptly in the morning and at noon and keep them going every day.

3. THE EDUCATION OF THE WORKMEN

It is presumed that the most intelligent and skilled of the men available will be selected for each position which is to be filled.

If, then, the inducement to hold their positions subsequently is sufficiently strong, it will naturally act as a stimulant for all to improve their talents and every encouragement on the part of the management should be manifested to aid them in their endeavor. Some of the larger and more progressive concerns have found it advantageous to establish schools in connection with their factories, where courses are given in technical and manual training which will aid the men to become more proficient in their work.

So much stress is being devoted to industrial education, however, in the correspondence, public and other schools that it will generally be necessary only to inspire the ambition of the men to improve their talents and to place them in the way of obtaining the benefits of facilities already existing.

The provision of literature, technical and popular, which may be taken home, will be a great help in this direction. A small charge can be made for keeping books out over a stated time. This charge acts as a reminder to return them and estab-

lishes a fund with which to secure new ones.

4. THE HEALTH OF THE WORKMEN

When it is realized that the health of the operative and his efficiency are co-relative it should not require much persuasion to get the management to devote considerable attention to those conditions about the factory buildings which will effect the comfort and health of its occupants. Good air and plenty of it at the right temperature, good light, convenient and sanitary lavatories, all come as a matter of course.

All of these, however, must be supplied intelligently. Air can be forced in so that draughts occasioned by it are not only discomforting but dangerous. Light may be accompanied by so much heat as to be uncomfortable. Lavatories may be so inconvenient and badly arranged as to be useless or unsanitary. In a large electric works, and in a steel works which I visited recently, I saw wash rooms which were so seldom used that the water had been shut off. In another, the use of roller towels had resulted in the spread of skin and blood diseases. Rest rooms for the accommodation of those temporarily indisposed prevent the loss of valuable time. Coat rooms where damp clothes can be changed for dry ones, and the operatives are encouraged to provide themselves with dry stockings and slippers, will be conducive to increased efficiency on wet days. There is nothing so distracting as cold feet, and the lowering of vitality due to wet clothing invites pulmonary diseases which will cause absences and loss of time.

Exhaust fans for extracting dust and grit from polishing and grinding operations, safety appliances attached to machinery to prevent accidental catching of clothing or limbs, all are conducive to saving expense in the long run.

The segregation of the tuberculous, and the exclusion of those suspected of having been exposed to contagious diseases, are precautionary measures now being generally adopted. The examination of the eyes and teeth, and extending help to remedy their defects, will tend towards preventing absences and saving time.

Emergency rooms for administering first aid to the injured, by competent experts, prevent incipient wounds from developing into more serious maladies.

Occasional talks, by the physician of the Beneficial Society, on "how to live right," will prevent much sickness in the families of the operatives and so increase the percentage of attendance of those who are the wage-earners, a cheerful room with facilities for warming their lunch and where the operatives may gather for their midday meal, with the provision of free coffee and tea, will tend to make the afternoon hours productive of better results than if they are left to themselves to eat a cold lunch, with, perhaps, the accompaniment of stronger stimulants.

The drink habit has become of late years such a serious menace to discipline and an obstacle to efficiency, that many concerns have taken the stand squarely that they will not employ or retain in service any one who is addicted to alcohol or other drugs. The habit should, however, be looked upon as a curable disease rather than a vice, and every effort made to help individuals to effect a cure rather than perfunctorily to turn them out of the community for the public to handle. A man helped to free himself from the chains of intemperance will make a loyal adherent to the company's interests.

5. THE HOUSING OF THE WORKMEN

This subject is given little or no thought by the average employer. It should be realized, however, that the hours spent away from the factory affect those spent at work.

For this reason every assistance should be extended to the men to enable them to secure reasonable and sanitary lodgings, so located that the

transportation to and from work will not be irksome or expensive. The workmen should arrive at the factory fresh and anxious to pick up their implements and get to work rather than sleepy from a night of poor rest or tired from a toilsome journey.

Sometimes, owing to the isolated location of the plant or a dearth of lodging houses in the neighborhood, it will be advantageous to provide houses, and should this be the case care should be taken to see that they are supplied at a reasonable rental and that they are neat and attractive. A bonus for the best kept house and surroundings, paid monthly, will prove a good investment, as a saving in upkeep is thereby accomplished.

6. THE SOCIETY OF THE WORKMEN

Man is a social animal by nature. It is desirable for his mental and moral health and growth that he associate with his fellows, and indulge with them in pleasurable recreation. Often it will be found that in the effort to assuage this craving bad associations are formed and it will be found desirable to assist the employees to form social organizations, offering rooms in the factory building for gatherings, where they can listen to educational or popular addresses, attend social gatherings where music and dancing are enjoyed. The attendance at all such gatherings must be purely voluntary and the attractions of such a character as to "draw." When these affairs are left to the people themselves, extending only such assistance as may be requested, the best results are attained.

7. THE PROTECTION OF THE WORKMEN

Every organization, every group of individuals, contains at least one person whose ideas of fair-dealing vary so much from those of the rest that if he has a position of vantage over the others they will need protection from his acts. Every community contains people whose shrewdness is so overdeveloped that they take undue and unexpected advantage of every one with whom they come in contact. Protection against the grasping tendencies of such people is necessary on the part of those who are practically helpless from ignorance or lack of moral or financial ability to resist.

Every industrial enterprise or community contains men who are misfits—more successful as political leaders than mechanics, who, failing to obtain success in their trade, become disturbing influences and agitate trouble among those whose reasoning powers are less developed than their passions and sentimental tendencies. The latter must be educated to see conditions from a broad viewpoint, so as to penetrate the superficial arguments of the demagogue and ally their interests with those of the company so that they can be mutual.

The services of an attorney placed at the disposal of the employees at a nominal sum will be of enormous benefit to them, and if the man is tactful and can secure the confidence of the workmen he can be a power towards keeping the organization cooperative and loyal.

Petty subscriptions started in the works for all sorts of purposes, which sometimes become a drain upon the employees, can be controlled by prohibiting all except those permitted by the "works committee."

Bulletin boards on which are posted the minutes of the meetings of the various committees insure publicity, and establish public opinion, so that principles rather than rules govern the plant.

It is evident that in order to obtain the highest efficiency of the employee, his undivided and enthusiastic interest must be secured in his work. The employer must, therefore, do all in his power to contribute to his peace of mind, so that his thoughts will not be divided from his work.

The principal causes of worry which the employer can do much to

relieve are the overbearing and dictatorial attitude of foremen, possible reduction of wages, loss of position, accident during occupation, and its resultant effect upon the fortunes of the family, loss of health from the effects of unsanitary conditions attending working operations. Some of the means by which relief can be secured have been mentioned, but in addition the employer may establish a fund for insurance against accident and sickness, and one for pensions for long service and old age.

How far outside of the factory the influence of the employer can be felt in these same directions will be a matter for the individual employer to determine. That he is responsible for having secured the presence of the employee in his factory is recognized, and it is, therefore, his duty to himself and to his company to secure the employee's highest efficiency; but as he is also accountable for having brought the employee into the community where the factory is located, it is also his duty to see that this efficiency is not secured at the expense of this individual or this community.

All of this means, besides a knowledge of competent management on the part of the employer, a full realization of the obligations of citizenship not only as they apply to his employees, but as they are related to the State and the Nation.

Many people fear that a crisis is impending in the conflict between capital and labor, and point to the standing armies, composed of the combinations of manufacturers on one side and the trade unions on the other.

I am not among those who look for a general revolution, although I expect there will continue to be many clashes at arms between these two bodies whenever a manufacturer becomes despotic or a labour union arbitrary. I have seen the results of representative methods of management and know that they are preventive of so-called labour troubles. I have seen how easily these methods can be introduced. What I hope and expect to see is an evolution to these representative methods brought about by the education of men in competent management in the economic schools now being established in the representative colleges

STEEL SHEET PILING

By J. F. Springer

III. APPLICATIONS OF SHEET PILING IN GERMANY

Although Germany seems to have been the country where the sheet pile formed of steel was first applied to practical use, yet the German engineers did not, apparently, at once adopt it with any unanimity. However, about the time the Americans began to get awake to the value of steel sheetings we find that their Teutonic cousins likewise became alert. Thus in 1904, at the very considerable port Bremen, a length of 1,050 feet of steel sheet piling was constructed as a retaining wall along the shore. The soil was known to become difficult of penetration at a considerable dept, because of a local gravel bed. In fact, a couple of years previous it seems that this circumstance compelled a recourse to steel sheet piles. The piling thus used was, however, of a fabricated type and consisted of I-beams and channel bars. Now it was proposed to introduce a newer style—the Larssen sheeting. In favor of the later development in piling were two prominent considerations: (1) the cost would be less, and (2) the stiffness of the section greater. Thus the older type is said to have weighed 47.9 pounds per average square foot of finished surface, while the Larssen piling only weighed 27.1 pounds. The moments of resistance were in the ratio of 6 : 7 and in favor of the new form.

The illustrations show the manner in which the Larssen piles have been used in connection with improvement works on the Weser, near Bremen. The old slope of the shore is indicated. This was, apparently, retained for the most part back of the line of piling. Subsequently to the driving of the piles, the soil in front of them was dredged to the depth of 26 feet, thus accommodating very considerable vessels close up to shore. There was a railway track located at the top of the incline above the piles. The slope was at an inclination of 1 : 2. The wall of steel sheeting made it possible to have deep water at a horizontal distance of about 30 feet from the center of this track. Of course, the pressure of the water and that of the strata back of the piling tended to neutralize each other. But this was not relied on to maintain the integrity of the steel wall. A line of walling was run along the top and the piling anchored by means of land ties. The piles were about 29 feet long and were driven to a point about 6½ feet below the general level of the subsequent dredging. The tops of the piles were, at the completion of operations, about 5 feet below the high water mark.

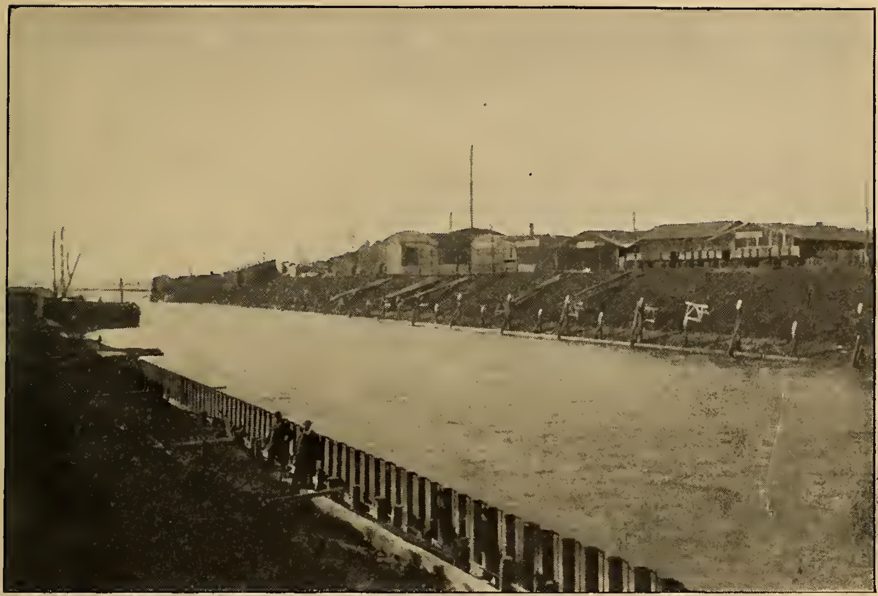
This sheeting was found to be not only impervious as to the retained soil, but also as to water. The tide at this locality varies nearly 6 feet, so that a disturbance of the pressure front and back would become quite pronounced. The withdrawal of six feet of water from the front of the sheeting would mean the withdrawal of 375 pounds of resistance per linear foot. If the pressure from the shore side should become, for any reason, strongly effective, this might prove a troublesome condition. So

SHEET PILING, LARSSEN SYSTEM, ON THE LOWER WESER, NEAR BREMEN

complete was the watertightness ot the sheeting found to be that it was deemed best in subsequent construction to make openings for the drainage of water from the rear of the wall of piles.

In spite of the tough and firm layer of gravel about a yard in thick-

LARSSEN SHEET PILING ON THE WERDERDAMM AT BREMEN



RETAINING WALL OF LARSSEN PILING, PRIOR TO FILLING EARTH BACKING

ness, no real difficulty was experienced in driving the piles. At a depth of about 25 feet a root about 4 inches in diameter was encountered, but was cut through smoothly. The ease of penetration of the Larssen form is due to its smooth surface.

The cost of this construction per

LARSSEN SHEET PILING ON THE WOLTMERSHAUSER CANAL, NEAR BREMEN

RETAINING WALL CONSTRUCTION ON THE WOLTMERSHAUSER CANAL

square foot of finished wall may be tabulated as follows:

Sheet piling...........	$0.540
Land-tieing and bracing.	.135
Driving, etc...........	.191
Total	$0.666

A further application of the same piling was made in the same district in the following year by the construction of a permanent retaining wall of similar character. The old slope which was retained for the upper part of the work was the same as before, but there was imposed a heavier load above the retaining wall because it rose to a greater height. Consequently it seemed necessary to provide superior resistance for a probable superior horizontal thrust. Consequently the thickness of the piling was increased from 0.39 inch to .43 inch. The weight was accordingly increased from 27.1 pounds to 30.2 pounds per square foot. These piles were 39 feet in length, and when in place projected above high water. The length of wall constructed here was about 877 feet. There was provided a retaining surface of about 2,850 square feet, part of which is perpetually submerged, part is alternately submerged and exposed, and part is perpetually exposed. As the heads of the piles rose past the face of the slope, a filling was provided behind.

As to cost, the following table supplies details per square foot:

Sheet piling...........	$0.585
Land-tieing and bracing.	.225
Driving, etc...........	.191
Total	$1.001

The last item is the same as before. The increased cost of the piling itself is understandable on account of the augmentation of the weight. It will be noticed, however, that the amount for land-tieing and bracing is very considerably increased—67%.

Two other smaller constructions were carried out in the same vicinity during the same year (1905). In both, the length of pile and thickness of metal were reduced. Both formed retaining walls for the municipal sand piles at the water front. The lengths

DRIVING LARSSEN PILES ON THE WOLTMERSHAUSER CANAL, BREMEN

of wall were, respectively, about 868 feet and 195 feet.

In these four applications of the Larssen piling at Bremen, a total weight of sheeting amounting to about 1,146 short tons was used. There was a total length of wall of about 2,990 feet. The whole is permanent construction, and a great deal is exposed to the varying conditions of wind and wave. No real difficulty seems to have been experienced in driving the Larssen piling to place.

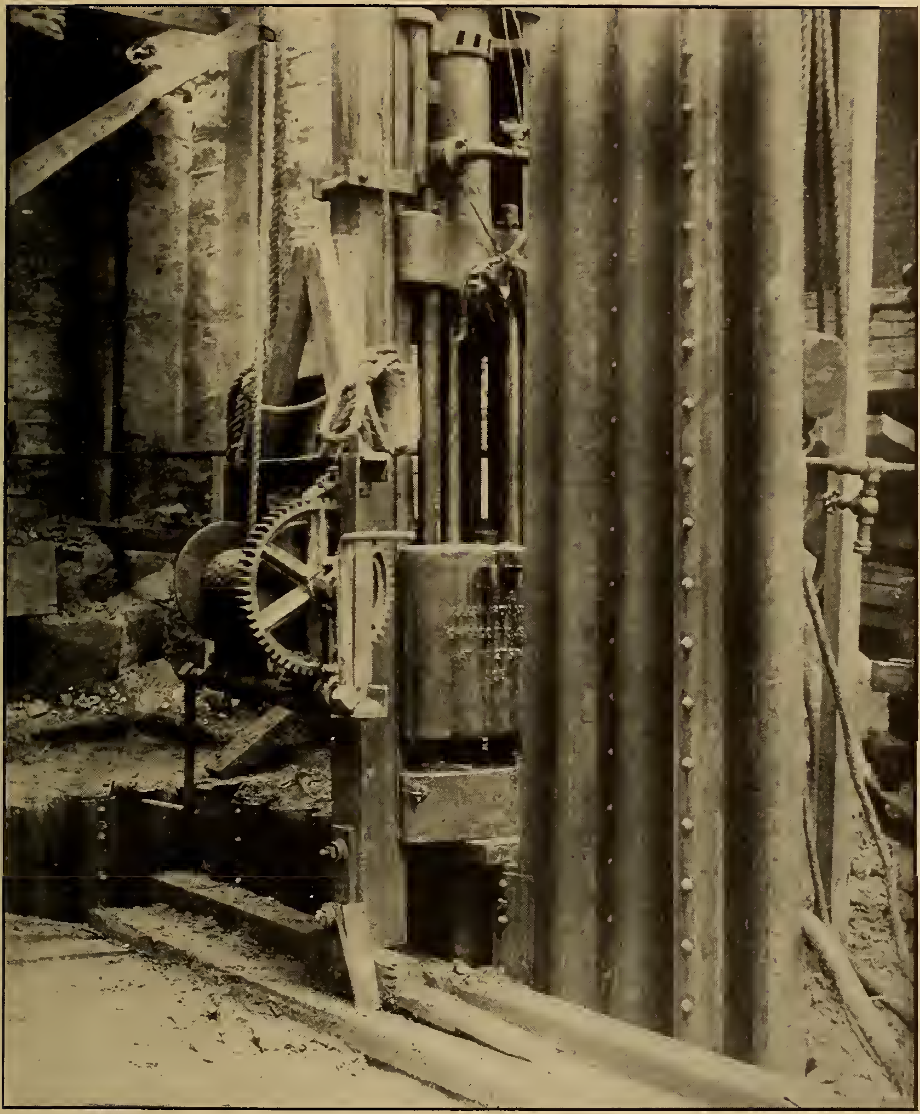
To secure certain buildings of a private firm in Bremen against the action of the water a line of Larssen piling was driven. Two prominent considerations entered here. First, there were a good many stones in the soil to be penetrated, and second, it was advisable to avoid the serious jarring of the earth which accompanies the hard driving of wooden piling. And steel sheeting is admirably adapted to meet both considerations. In still other construction at Bremen, the Larssen piling has been found serviceable. In one of these cases the length of the piles was 47 feet, while actual penetration into the soil was about 36 feet. In seeking to make this piling absolutely watertight, one has the sheets prepared in such a way that a recess is left in the interlock. This may be filled, before driving, with clay, asphaltum or the like, suiting the sealing material to the conditions. If the construction is merely temporary clay may be used; if permanent, some other sealing substance should be selected, since the amount of clay used for the seal is too small to be relied on for permanency.

In connection with the development of metallic sheet piling the question of the driving of the piles has to be considered. The older form, using the force of gravity upon a heavy weight, raised to a considerable height and allowed to fall upon the head of the pile, answered fairly well for timber piles driven into mud or soft earth. When, however, this method was used for wooden sheet piling driven down

AN EXAMPLE OF THE CONDITION OF WOODEN SHEET PILING AFTER AN ATTEMPT TO DRIVE IN HARD BOTTOM

to hard bottom, it was found that the results were unsatisfactory and the illustration shows how timber piles have been damaged by attempts to drive them under such conditions.

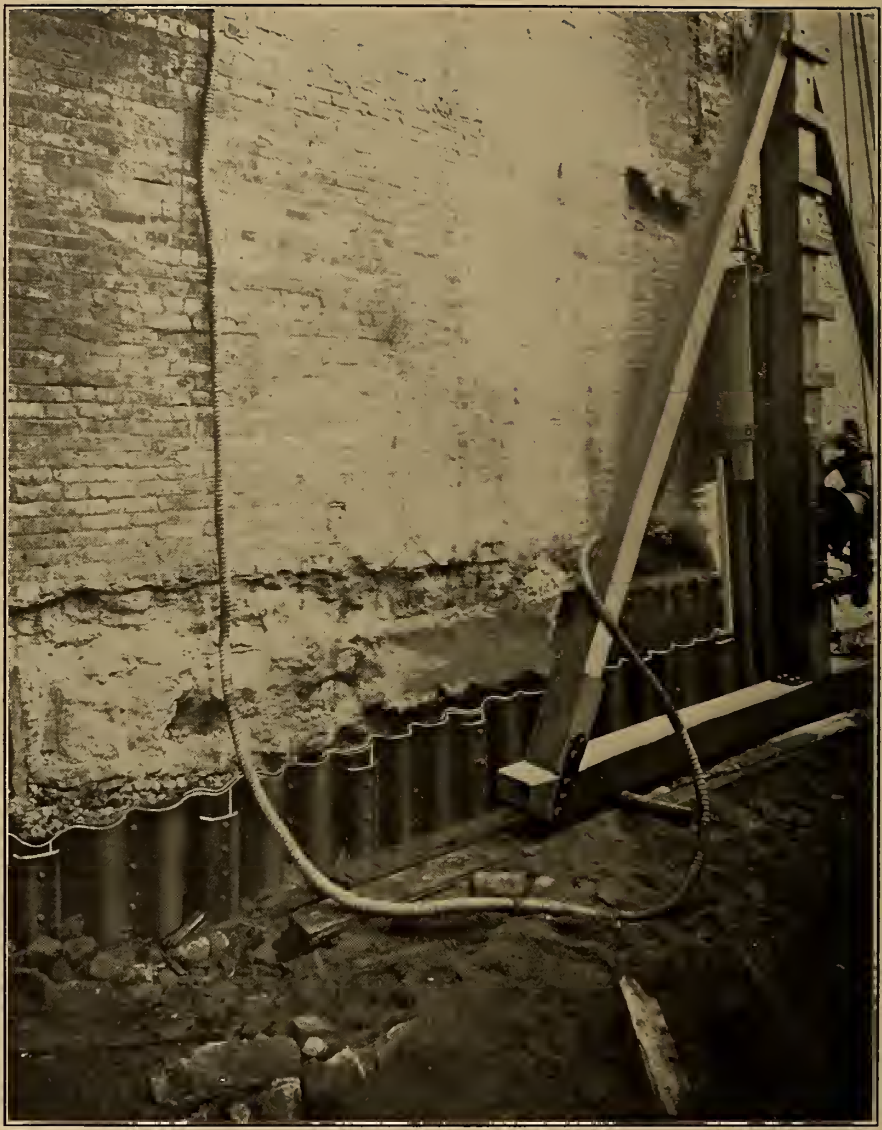
It is now well understood that a portion of the supporting power of a pile is due to the friction of its sides against the earth, and the same frictional resistance which is utilized in this manner must also be overcome in driving. The resistance of the friction of rest is much greater than the resistance of friction during motion, and hence it is evident that if the blows of the ram are made to follow



VULCAN STEAM HAMMER DRIVING ⅛ INCH WEMLINGER STEEL SHEET PILING AT THE CITY NATIONAL BANK BUILDING, NEW YORK CITY

each other so rapidly that the pile does not have time to come to rest between them, much time will be saved in the operation of driving and much less injury produced upon the pile. As soon as the operation of driving ceases, the earth closes in upon the pile and the full sustaining effect of the frictional grip is secured.

The modern pile hammers, several types of which have been illustrated in these articles, are designed so as to be self-contained, the frame containing the cylinder and the ram being attached to the piston rod so that it is positively operated both up and down, the motive power being either steam or compressed air. Such machines enable speeds of two hundred blows a minute to be delivered, and



NEW MONARCH HAMMER, DRIVING PILING FOR RETAINING WALL, MUNICIPAL BUILDING. HENRY J. MCCOY COMPANY, NEW YORK

their compactness and power have materially aided in the commercial use of sheet piling in general building work. While it is desirable that a pile hammer should be operated between fixed leaders, the self-contained feature of the modern machines enable them to be suspended from chain hoists or derricks, and thus employed in situations in which the erection of timber leaders would be difficult or costly. The small head room required by these modern machines has proved desirable, as permitting the use of longer piles than could otherwise be driven in some contracted situations.

THE SCOTTISH GRANITE INDUSTRY

By William Diack

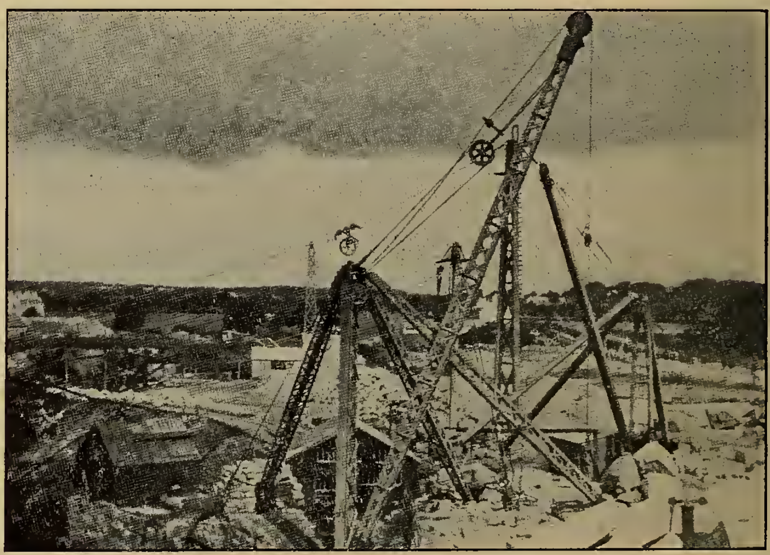
FOR more than a century now Aberdeenshire has been the centre of the granite industry of Britain. In Cornwall and Cumberland, in Kirkcudbrightshire and Argyllshire some interesting work has been produced in this refractory rock, but it is in the "Silver City by the Sea" that the art of granite cutting has reached its highest stage of development. It was here that the art of polishing granite was re-discovered after it had been lost for more than thirty centuries. It is in Aberdeenshire, too, that one finds the largest and best equipped quarries in Britain, and it is the products of the Aberdeen stoneyards that have carried the fame of British granite to the furthest ends of the earth. Sarcophagi of Aberdeenshire granite hold the dust of kings and emperors. On the South African veldt and on the desert wastes of Atbara, artistically designed memorials hewn out of this stubborn rock mark the last resting places of soldier heroes. In our great cities at home one sees monuments of Aberdeenshire granite that may well out-last the fame of the statesmen whose deeds they commemorate. In our great public buildings magnificent polished columns of Peterhead granite take a notable place in the decorative scheme, and on the spacious streets and squares of continental capitals striking examples of Aberdeenshire granite work may also be seen. For wharves and dock-work it still holds its own, in spite of the competition, which grows keener every day, from the quarries of Norway and Sweden, while on scores of lighthouses around the coast the waves beat harmlessly against enduring walls of Aberdeenshire granite. In the quarries as in the polishing yards, machinery nowadays plays a notable part. In the early years of last century granite was quarried and cut by laborious methods which differed little, if at all, from the system in vogue among the old Egyptians thirty centuries ago. But in quarrying operations to-day powerful rock drills driven by steam, compressed air or electricity have displaced the hand "jumpers" of former days, and in a modern quarry manual labour has been reduced to a minimum.

The general appearance of a modern rock drill is well known. It consists of a cylinder in which a piston is made to move upwards and downwards, by means of steam or compressed air. At the lower end of the piston is a head chuck into which the drill bit is fitted, the whole being secured to a powerful tripod frame heavily weighted. These drills are capable of delivering 400 strokes per minute, and will bore a hole from 2 in. to 3 in. in diameter through the solid rock at a speed of eight feet per hour, piercing downwards if necessary to a depth of 25 feet. The drill bits are made of various sizes. For commencing a hole one of 9 in. long and 3¼ in. in diameter will suffice. Then as the hole grows deeper, this is replaced by a longer one, a new bit being put in with every additional foot of rock drilled. To facilitate the working, the diameter of the drill becomes gradually smaller as the hole grows deeper, and by the time a depth of 20 or 25 feet is reached may be reduced from 3¼ in. at the top to 2 in. at the bottom.

The saving of time and labour by means of these drills is remarkable By means of these appliances one man in a single hour can do as much work as a drilling squad of three men could do in a whole summer's day. Not only so, but the work is done much more efficiently, for, as will be readily understood, it is almost a physical impossibility to drill a hole 20 feet deep by means of manual labour.

The number of holes necessary to dislodge a piece of rock varies, of course, according to its size—as many as a dozen may sometimes be required, though three or four will usually suffice. Into these holes charges of coarse gunpowder are placed, as higher grade explosives would shatter the rock too much. The "shot" is fired by electricity and the amount of powder used is so accurately gauged that the rock is not at first dislodged, but rather riven asunder, a deep fissure perhaps not more than half an inch in width being formed at the back of the massive boulder about to be quarried. Into this aperture a second charge of powder is placed, and this when exploded slowly dislodges the piece of rock so that the least possible damage is done by the explosive to the finely grained granite.

Sometimes, however, when a larger block than usual is required, firing by mine is resorted to. A few years ago a gigantic blast of this kind took place at Kemnay quarries, some six teen miles from Aberdeen. The rock was first pierced from the face with a horizontal tunnel extending all along the length of the mass of granite about to be quarried. Jutting out from this tunnel smaller side tunnels were cut along the intended line of rupture. Into the tunnels were placed two and a half tons of gunpowder, the different charges being fired simultaneously by means of electricity. By this means 70,000 tons of granite were quarried by a single blast. Some idea of the mass of granite thus dislodged may be gathered from the fact that nearly 3,000 railway wagons were required for its transport on a single train over 30 miles in length.



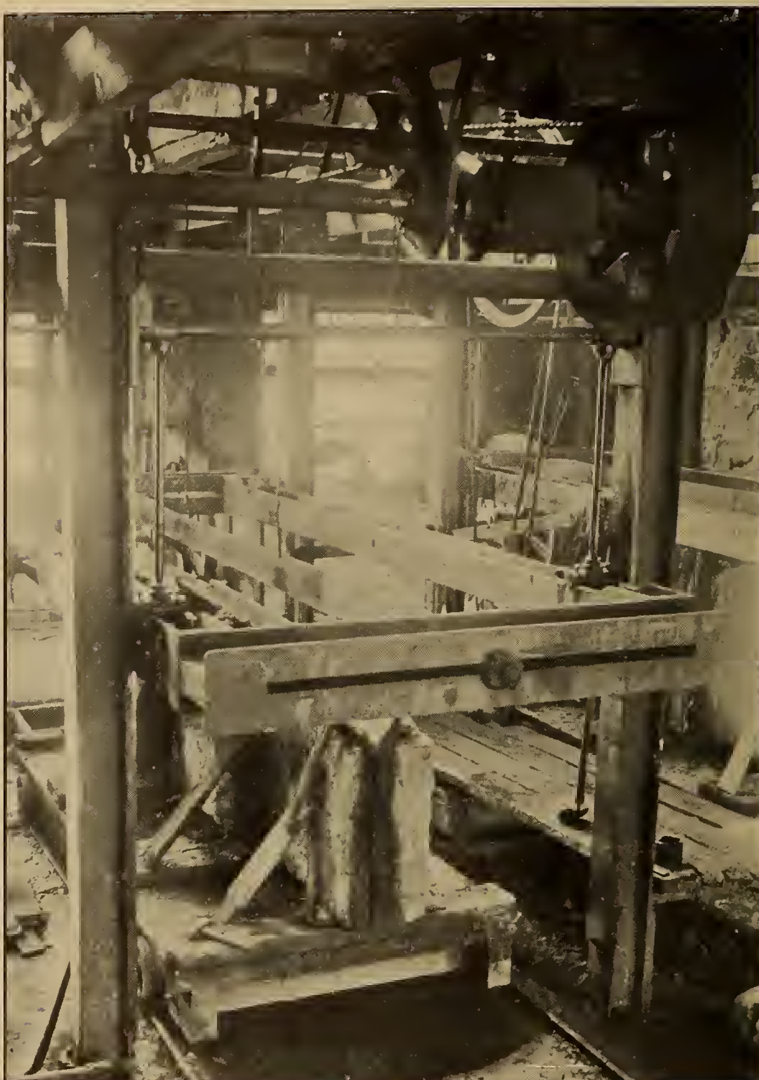
TWENTY-TON ELECTRIC CRANE AT RUBISLAW QUARRY

When the shots have been fired, the stones are cleared away as quickly as possible from the floor

of the quarry—the larger blocks for monumental and engineering work, the smaller stones for building purposes, curbing and paving sets. Even the stones which the builders have rejected are not wasted. In some of the quarries the chips and spalls are ground into dust and used for making "adamant" and other kinds of artificial paving. The stones are lifted from the bottom of the quarry, and conveyed to the loading banks by means of aerial cableways and powerful steam or electric cranes. These "blondins" or cableways are an interesting feature of the Aberdeenshire quarries, and greatly facilitate operations, particularly in the deeper openings. The cableway was first used in quarrying work by the late Mr. John Fyfe of Kemnay; indeed it is generally claimed that the "blondin" tackle was invented by this famous Scottish quarry-master. Certain it is, he designed the first modern cableway in Scotland, and he often told with pride how one of his old employees, now a leading quarry-master in the United States, saw this ingenious contrivance at work at Kemnay when on a visit to his native land, and on his return to America promptly utilized it for quarrying work in the contracts on which he was then engaged. Thus the "blondin" soon became as familiar a feature in the quarries of the United States as it is to-day in Britain. The "blondin" is constructed on the principle of the suspension bridge. A massive wire cable stretches from the farther edge of the quarry right across the pit, and over a lofty tower beyond the loading bank. Both ends of this rope are, of course, securely anchored. On this cable runs a traveling carriage driven to and fro by a winding engine. To the carriage are affixed a traveling rope and a hoisting rope. The hoisting rope may be lowered at any point required and attached to the huge blocks of granite or to the loads of chips and refuse. These can then be raised, if necessary, from a depth of 200 to 300 feet, drawn along the cableway and deposited on the loading bank or at whatever point may be required. In Mr. Fyfe's quarries at Kemnay, one of these "blondin" transporters has a span of 945 feet and is capable of lifting a load of 8 tons. At Sclattie, in the vicinity of Aberdeen, a "blondin" with a span of 575 feet and a lifting capacity of 12 tons dips into the bowels of the quarry. The "blondin" is now in almost universal use in the quarrying trade at home and abroad, and has also been successfully employed at the building of the Vauxhall and Kew bridges in London, as well as in other important engineering undertakings.

In most of the Aberdeenshire quarries steam is the usual motive power, but at Rubislaw this has been displaced by electricity, the supply being taken direct from the Corporation main. Altogether about 1000 horsepower electric machinery has been laid down with highly satisfactory results. A complete air compressing plant driven by 100 horse-power electric motor has been installed for working the rock drills and the smaller hand drills used for splitting and "blocking" into shape the larger masses of granite. Electric motors are also fitted into each of the cranes, one of which is capable of lifting a load of 20 tons from a depth of over 300 feet.

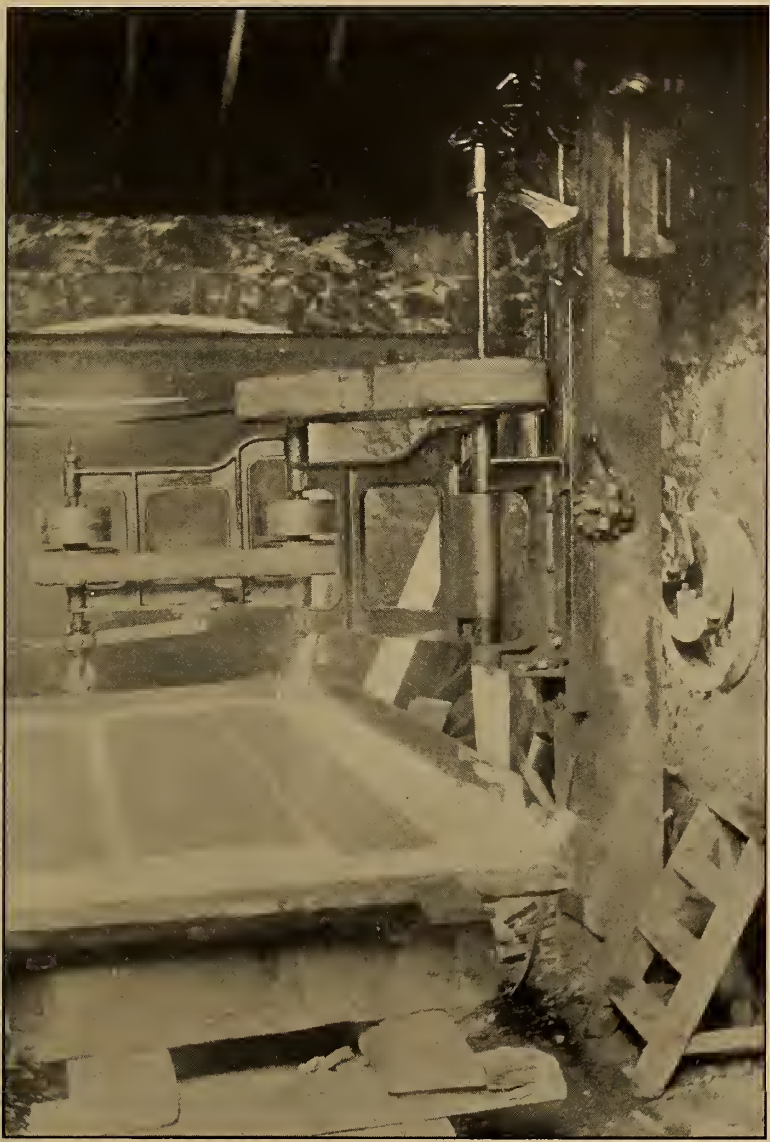
Those whose steps may be directed by business or pleasure towards the Granite City may spend a profitable hour or two in visiting one of the many stoneyards where the native rock is carved and polished. A glance at the busy, bustling scene will serve to show the world-wide ramifications of the industry. In the centre of the yard is a goodly store of massive blocks of unhewn granite, not from the quarries of Aberdeenshire only, but from Norway. Sweden and Russia as well. Importing granite to Aberdeen may seem like "carrying coals to Newcastle," but nevertheless the amount of



A GRANITE SAW AT WORK

foreign material which entered the stone-yards of Aberdeen last year was no less than 27,000 tons—and 1908 may be taken as a normal year in this respect. From the great hills of granite on the rock-bound coasts of Sweden and Norway huge blocks of stone may be obtained with much less trouble and expense than, say, from the neighbouring quarries at Peterhead, some 40 miles distant. In busy seasons, when the demand for big blocks of granite has been greater than the local quarries could cope with, the Aberdeen granite merchants have very readily taken advantage of the foreign supplies available. Moreover, the greater variety of colour and quality of granite thus obtained is, of course, distinctly advantageous from a decorative point of view.

By means of steam derricks or traveling cranes, the rough blocks of granite are quickly transported to



GRANITE POLISHING MACHINERY

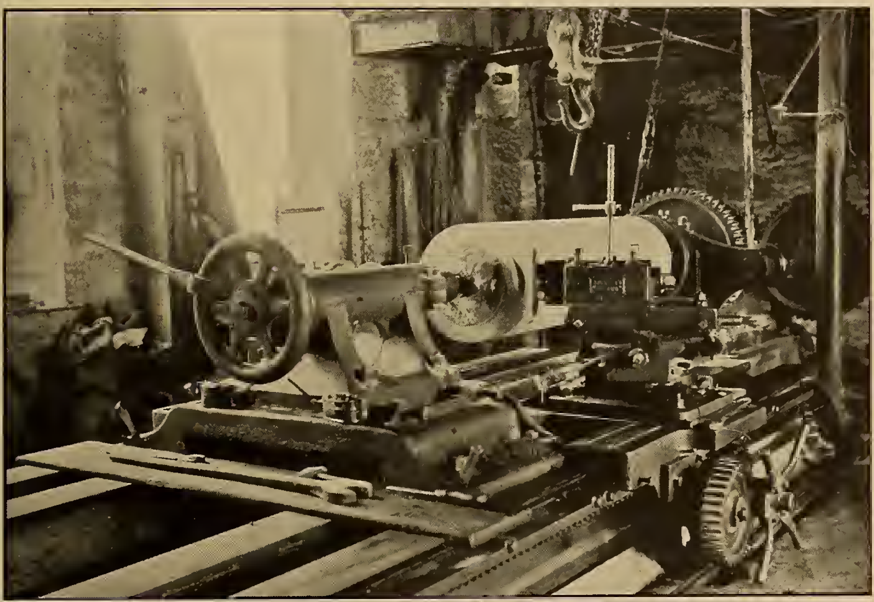
the work sheds, there to be cut, sawn or turned into stately columns, richly carved crosses or elaborately polished memorials. The granite "saw" is one of the most interesting appliances in an up-to-date stone-yard. It has no teeth like an ordinary saw, but its construction and manner of working are exceedingly simple. The block of stone about to be cut is first placed on a massive "bogey" or carriage and wheeled underneath the saw. The saw itself is simply a strong steel blade about half an inch thick and two or three feet longer than the stone about to be sawn. The lower edge is perfectly smooth and even, the actual cutting being done by an abrasive in the shape of "iron sand" or grit—small rough grains of

chilled metal not unlike round shot. Propelled by steam, the heavy saw swings backwards and forwards over the surface of the stone, pressing heavily the while on the grit. Water is freely poured into the saw-cut, and soon with the grit and dust forms a thick sludge, which is steadily ladled into the rut by the workmen in charge. It can scarcely be said that granite sawing is a rapid process. In the early days of the industry when ordinary sand was used as an abrasive, the cutting of a block of granite four to five feet in depth occupied not days but weeks. Even now, with more powerful appliances, it takes two busy days of ten hours each to saw a block of granite 4 feet in depth and say 5 feet in length. The operation, however, is a profitable one, for immediately the work is finished the two sawn surfaces are ready for polishing without any manual labour whatever on the part of the granite cutter. Moreover, by means of the saw, blocks as thin as 3 in. or 4 in. may be easily obtained, thus effecting a considerable saving, both of labour and material.

For polishing granite, machinery is, of course, very largely used nowadays. Quite a revolution has been effected in the industry in this respect since the days when Alexander Macdonald, son of a Perthshire crofter, re-discovered the long-lost secret and founded the granite polishing industry of Aberdeen seventy years ago. It was in 1832 that Mr. Macdonald dispatched the first polished granite monument from Aberdeen to London, and it still stands in Kensal Green Cemetery as bright and glossy as on the day it was first erected. At that time the actual polishing was all done by manual labour —hard, fatiguing work, admirably adapted for apostles of the strenuous life. To-day, however, the Jenny Lind and the Pendulum machine are in general use in the granite yards of Britain and America. In the actual polishing, three simple processes are involved. If the surface to be polished is a plane, the block of granite is fixed to a massive frame and placed with the face uppermost underneath the polishing machine. By means of circular metal discs, all connected with one another and revolving rapidly on the same plane, iron grit and sludge is rubbed firmly over the surface until comparative smoothness is obtained. Emery powder is then substituted for the grit, and the polishing process continued until a dull gloss begins to show itself on the surface of the stone. All the sludge and emery is next washed carefully off, and by means of wet felt attached to the revolving metal discs, the surface is vigorously polished with putty powder—generally oxide of tin or tripoli—and the rich and beautiful gloss so much admired is at last obtained. For polishing mouldings a different process has, of course, to be adopted. A metal cast of the moulding is first made, and is firmly secured to a long overhead wrought iron arm. The moulding is placed in position and propelled by machinery, the iron arm with casting attached swings backward and forward over the iron sand or emery with a pendulum-like motion from which the machine derives its name. When elaborately carved work has to be polished, the primitive method of hand-rubbing with sludge and emery paste must perforce be adopted. The process is slow and the work laborious, but nevertheless a considerable amount of beautifully polished carved work is exported from Aberdeen to the Continent annually.

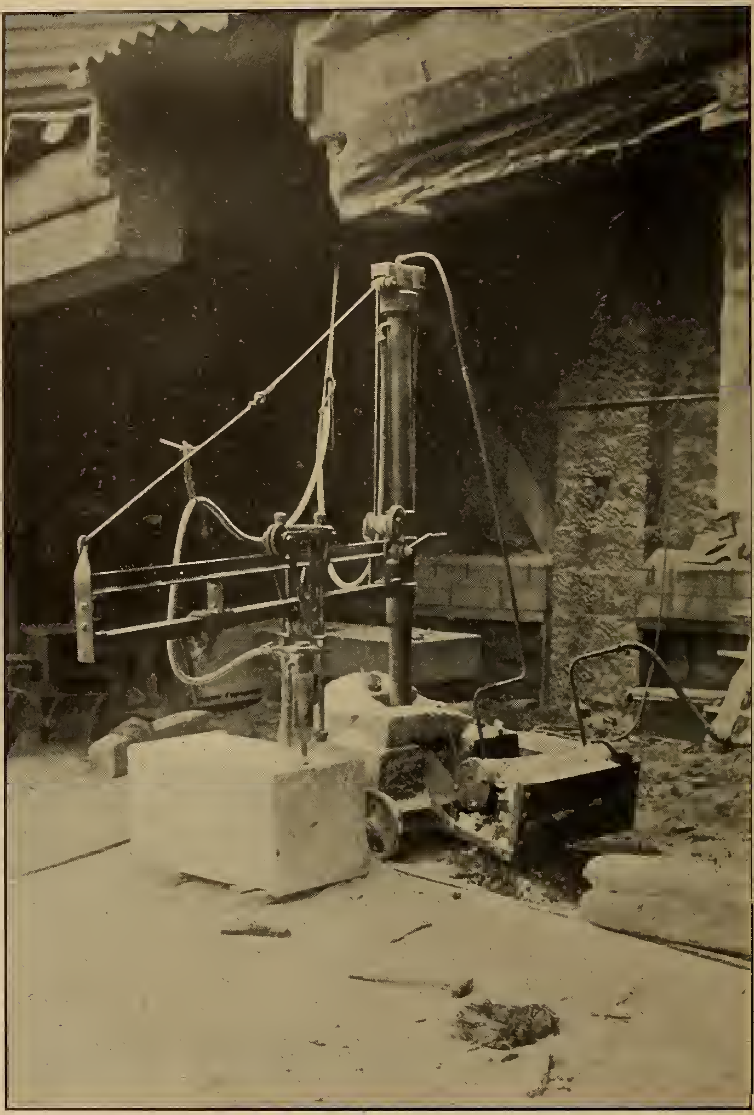
In the Carlton Club in London, in St. George's Hall, Liverpool, and in many famous public buildings in England and elsewhere one may see remarkably fine examples of granite columns turned and polished in Aberdeenshire stone-yards. The process of transforming rough, unhewn boulders from Rubislaw or Stirlinghill into these gorgeously polished columns and capitals is an exceedingly interesting one. The huge block of stone, perhaps 15 to 18 feet

in length and 4 feet in diameter, is first hewn roughly with blocking hammer, mall and puncheon into something approaching the required shape. This done, it is conveyed by means of a powerful traveling crane to the turning lathe. In this lathe the actual cutting is done by two circular cast steel discs, placed on opposite sides of the column so that the pressure of the one acts a counterpoise to the other. Through a hole in the centre of the cutter is placed a spindle with a boss, and this is screwed tightly up within the tapered opening. The column is turned by steam power, and as it moves steadily round, it gives a rotary motion to the cutters. The cutters strike the stone at an oblique angle, and soon a dull, grinding noise tells that the roughly hewn column is being slowly but surely fashioned into the required shape. As the circumference of the column becomes gradually smaller, the cutters are screwed still more tightly on to the revolving mass of granite. These powerful lathes are capable of doing the work of twelve to fifteen granite cutters working by hand, and by means of them elaborately moulded capitals as well as stately columns are cut and turned. When the column or capital has been fashioned into the required shape on the turning lathe and a comparatively smooth surface obtained, it is removed to an ordinary lathe and polished with iron sand and emery in the manner already described, the materials being applied by means of cast iron plates shaped to fit the column.



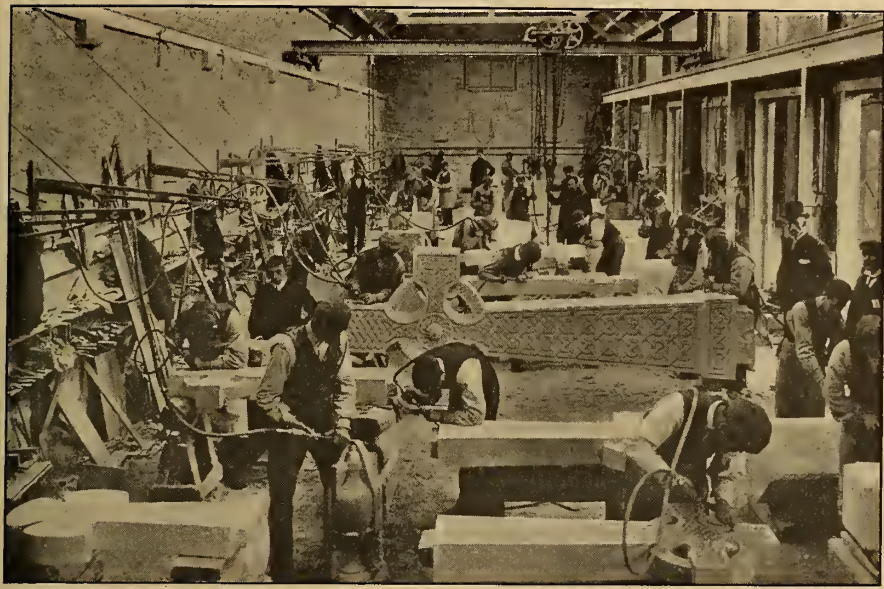
TURNING A COLUMN OF GRANITE IN A LATHE

As in the engineering, shipbuilding and allied industries, pneumatic tools are now largely used in granite cutting. Most of these are of American origin, although some of the most successful types have been designed and fitted up by Aberdeen engineers. For rough dressing work the "surfacing machine" is admirably adapted, although its strenuous, slap-dash manner of working is apt to "stun" the stone and thus destroy the beauty of the polished surface. The stone about to be "dressed" is first puncheoned down by hand to



PNEUMATIC GRANITE SURFACING MACHINE

within an inch or so of the required level. Then the surfacing machine is brought into requisition. In general appearance this machine reminds one of a miniature portable crane with an extending arm on which travels a carriage securely holding a large pneumatic hammer. Into the hammer a rough pointing tool is inserted and the air pressure applied. Soon a loud whirring noise tells that this wonderful stone-dresser has begun to do its work, and as the tool is moved backwards and forwards, to and fro, over the surface of the stone, the operator is enveloped in a cloud of dust and miniature chips. The rough surface is quickly reduced to comparative smoothness. A finer brush chisel is then inserted in the machine, and by this means a fine, even surface is quickly obtained—a surface suitable either for polishing or for finely axed work. Under proper conditions these



CARVING GRANITE WITH PNEUMATIC TOOLS

surfacing machines will point and brush 50 to 80 superficial feet per day.

For finer carving, lettering and decorative work generally, pneumatic tools now form an indispensable part of the plant of every well-equipped granite yard. The use of compressed air in stone cutting has reduced considerably the cost of high-class granite work and has opened up a wider field for the products of the Aberdeenshire stone-yards. With a pneumatic tool one granite cutter can do as much work as from four to six men hewing and carving by the old-fashioned methods, much, of course, depending on the nature of the work. To readers of CASSIER'S MAGAZINE there is, of course, no need to describe in detail the compressed air plant of a modern workshop. The air required to operate the tools is conveyed from the air compressor to the granite cutting sheds in metal piping. At convenient points these main pipes are tapped and the air conveyed to the operator in rubber tubes in the manner shown in the illustration. The pneumatic hammers are capable of delivering from 2,000 to 15,000 strokes per minute, and with them deft and skillful workmen may be seen fashioning with marvelous facility the hardest of granite. Classic examples of statuary, carved Runic crosses, wreaths of flowers, figures of bird and beast in bold relief—all these are produced with as much ease as from the softest of Italian marbles. But though the introduction of steam and compressed air has revolutionized the granite industry, a large amount of first-class work is still done by hand. In this case the stone is first puncheoned down to a rough surface and then finished off with chisels, axes and bush hammers, as may be required.

To mention even but a modest proportion of the famous granite monuments which have been executed in recent years would fill many pages and still leave much untold. A few examples may, however, be selected as showing the high stage of development which has been been reached by the Aberdeenshire granite cutters. Not the least interesting of these is the carved monolith in granite executed by command of the late Queen Victoria and erected at Bal-

moral in memory of the late Prince Henry of Battenberg. The beautiful sarcophagus, too, which holds the dust of Queen Victoria and the late Prince Consort was executed, many years ago now, in Aberdeenshire granite, and was at the time regarded as the best work of the kind ever produced in Britain. But the industry has made rapid strides since these early days. Many military memorials have also been dispatched to South Africa during the past half dozen years. A lofty obelisk of Peterhead granite marks the spot overlooking the little cemetery at Majesfontein where General Wauchope, the gallant commander of the Highland Brigade, lies buried. The graves of Prince Christian Victor, General Woodgate and valiant Dick Cunningham are also marked by memorials of Scottish granite. In recent years, too, some remarkably fine examples of granite statuary have been produced by Aberdeen stone-cutters. More than thirty years ago Messrs. Alexander Macdonald & Co. revived that long-lost art, the statue of the last Duke of Gordon, which stands in the Castlegate of Aberdeen, being the first statue cut in granite since the days of the Ptolemies. Another example is found in the handsome military memorial erected in South Africa in memory of the men of the Cape Mounted Rifles who fell in the Anglo-Boer War. It takes the form of the statue of a rifleman in full regimentals standing on a fluted Ionic column flanked on either side by African lions. This memorial, executed by Mr Taylor, Jute Street, may be justly described as the finest military memorial ever produced in an Aberdeenshire granite yard.

THE STEAM TURBINE IN THE GERMAN NAVY

By Fr. Bock

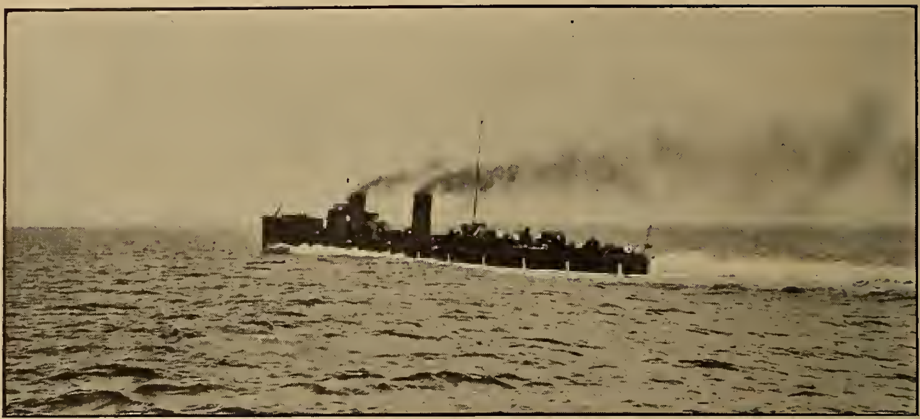
ALTHOUGH it is only a few years since the steam turbine was introduced into Germany, it has made its way rapidly. Already in stationary power plants the turbine has largely replaced the reciprocating engine, while torpedo boats and cruisers are being equipped, and the turbine will doubtless also be used exclusively for battle-ship propulsion.

In the spring of 1904 the Allgemeine Elektrizitats Gesellschaft commenced the construction of steam turbines, and at the present time this company employs 2,500 men in this department. Turbines as large as 12,000 horse-power have been constructed, and at the present time more than 120 turbo electric generating sets of 1,000 kilowatt capacity have been installed.

Having this extensive experience, the company has undertaken the construction of marine steam turbines, and the success obtained with the Curtis type for land service has convinced them of its availability for use at sea. The first vessel equipped with the Curtis turbine by this company was the steamer *Kaiser*, of the Hamburg-American line, this vessel having been constructed in 1905 at the Vulcan yards, at Stettin. The good results obtained with this boat led the Imperial Navy to try the system for torpedo boats, and subsequently for a cruiser. The engines designed for this service were thoroughly tried out in the testing room of the A. E. G. turbine department, and the trial trips of the boat, made in the autumn of 1908, were entirely satisfactory, the vessel exceeding the guaranteed contract speed of 30 knots by 3 knots. In consequence of this success a number of torpedo boats for the German Navy are being equipped with turbine propulsion.

At the German Marine Exposition the A. E. G. had an exhibit of the engine room of a torpedo boat, showing the simplicity of the steam turbine equipment for this service. In this exhibit was also shown the application of the steam turbine for the operation of all auxiliaries, demonstrating the advantages of the substitution of the noiseless turbine for the old-fashioned reciprocating auxiliary machinery.

The cruiser *Mainz*, built by the Vulcan works at Stettin, was the first cruiser of the German Navy to be equipped with the steam turbine, and every effort of the A. E. G. works was strained to complete its machinery within the allotted time. The *Mainz* was the first turbine cruiser to be fitted with only two shafts, all previous vessels of this kind having had three or four shafts. The use of two shafts permits an essential simplification of the machinery and its operation. The vessel is naturally much stiffer with the latter construction, and as each shaft has its own complete turbine they are independent of each other. The general arrangement of the A. E. G. turbine in a cruiser engine room is clearly shown in the illustration, this representing in general the arrangement adopted in the *Kaiser* and in the torpedo boats. The casing is divided into two parts, with the high-pressure turbine forward, and the low-pressure and reversing turbines aft, with a supporting bearing for the shaft between. In the high-pressure section the steam passes through a series of similar wheels, as in the ordinary A. E. G.

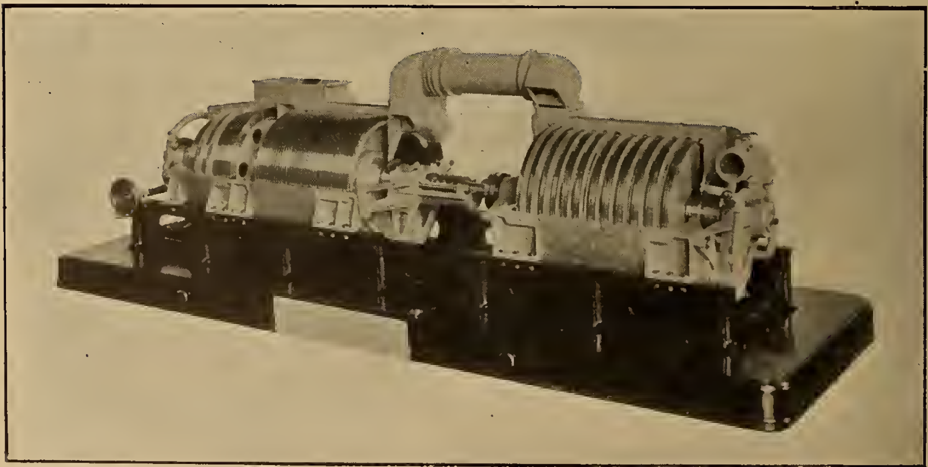


TORPEDO BOAT V.161, OF THE GERMAN NAVY; 6,000 HORSE-POWER, 560 REVOLUTIONS

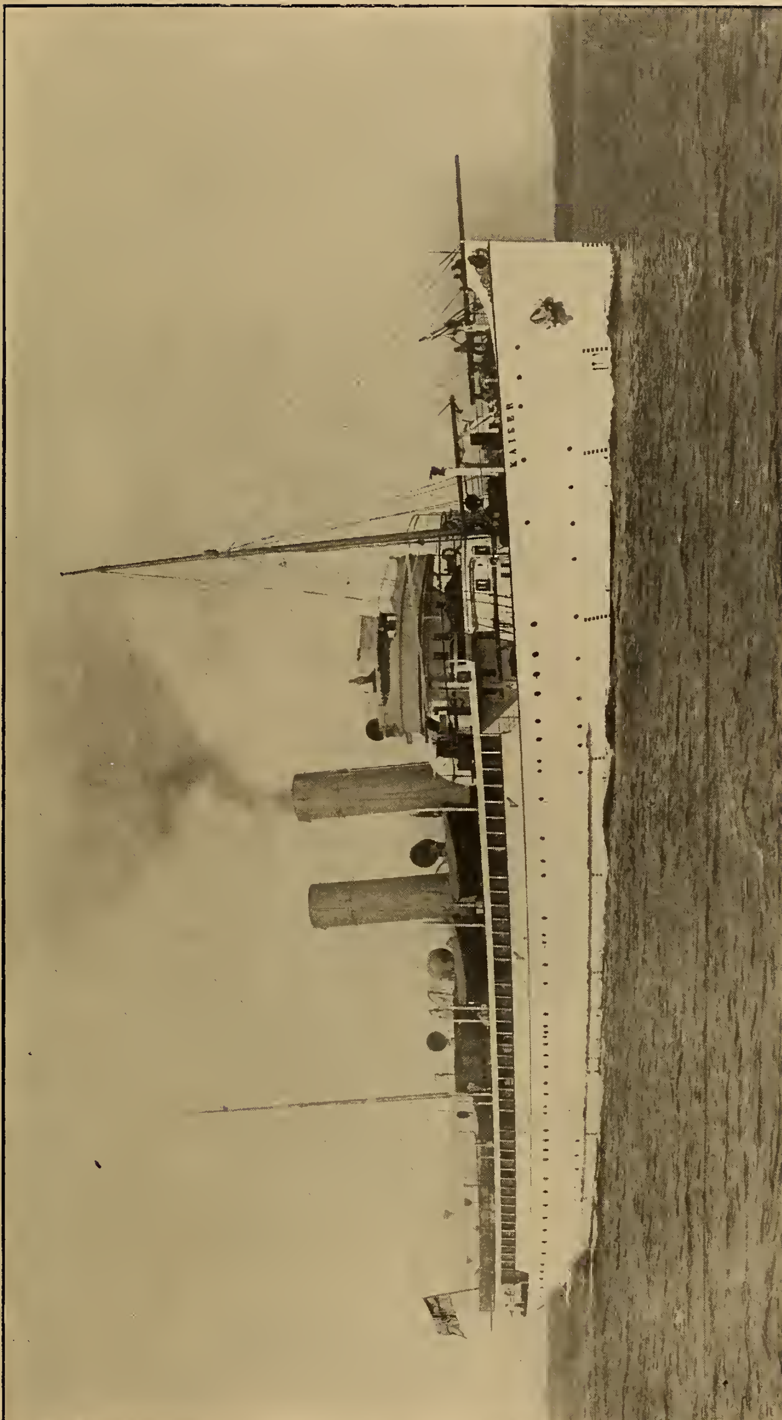
turbine, while in the low-pressure portion the expansion continues from one series of blades to another, there being a continual conversion of pressure into kinetic energy.

In the high-pressure portion there are separate partitions in the casing, each constituting a separate element, while in the low-pressure section the expansion takes place in the blades. Consequently the pressure of the steam acts to oppose the thrust of the screw when starting, and a similar action occurs in the reversing turbine. The parts are so proportioned that the thrust of the propeller is practically balanced when the engines are running at full speed.

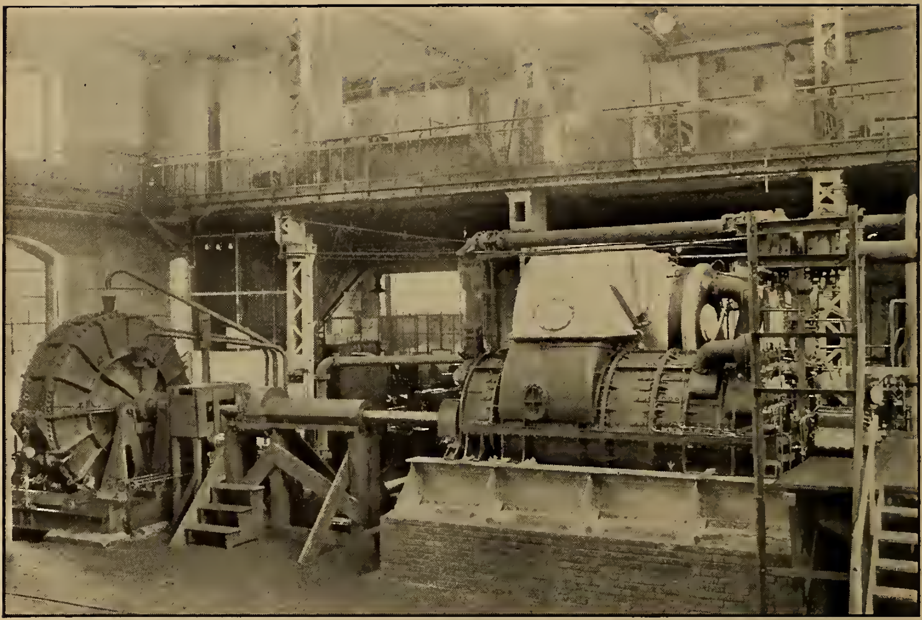
The temperature of the steam in the two portions of the turbine has been taken into account in the design of the machinery. In the high-pressure end the expansion of parts, due to high temperature, demands corresponding provision for both radial and longitudinal expansion. The rapid fall of temperature in the low-pressure portion has also to be taken care of, the expansion of the steam here taking place after its pressure has been util-



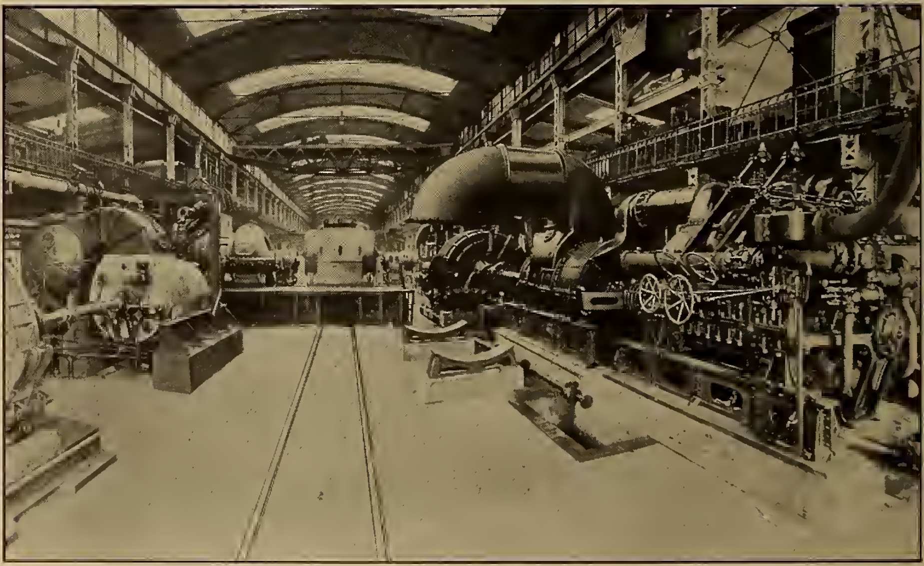
MODEL OF THE STEAM TURBINES OF THE CRUISER MAINZ, BUILT FOR THE GERMAN NAVY BY THE VULCAN WORKS AT STETTIN, AND ENGINED BY THE ALLGEMEINE ELEKTRICITATS GESELLSCHAFT



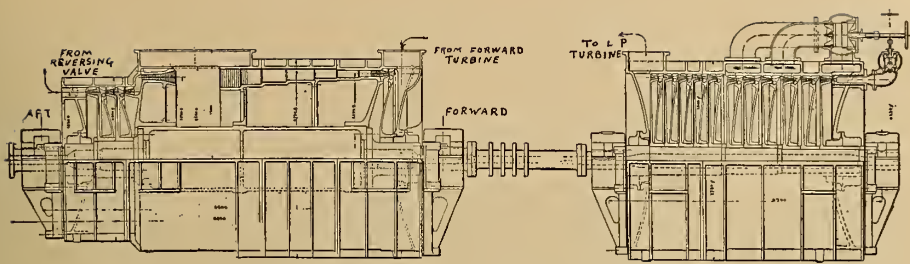
STEAMER "KAISER," OF THE HAMBURG-AMERICAN LINE. BUILT BY THE VULCAN WORKS, STETTIN, AND CONTAINING THE FIRST MARINE TURBINES BUILT BY THE A. E. G.



TURBINE ENGINE FOR TORPEDO BOAT V.161, IN TESTING ROOM OF A. E. G. WORKS AT BERLIN; 6,000 HORSE-POWER, 560 REVOLUTIONS



TESTING ROOM OF THE A. E. G., SHOWING ON THE RIGHT ONE OF THE TURBINE ENGINES OF THE "MAINZ," 12,000 HORSE-POWER. IN THE BACKGROUND IS A TURBO-DYNAMO OF 8,000 HORSE-POWER FOR NEWCASTLE, ENGLAND



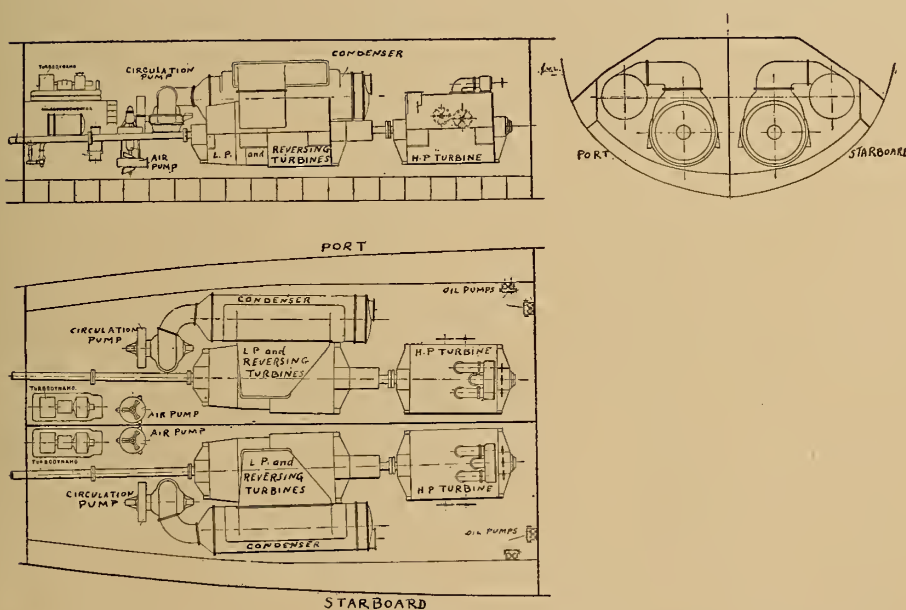
ARRANGEMENT OF A. E. G. MARINE STEAM TURBINES

ized in the high-pressure section, and the corresponding economy effected.

It is in these features that the A. E. G. turbine differs from the earlier machines. The Curtis marine turbine is still constructed without the expansion steps in the low-pressure portion, while the Parsons turbine has not yet made use of the short dimension arrangement in the high-pressure portion which has been found possible in these wheels.

The A. E. G. turbines are noteworthy for their solid construction and for the high grade of material employed. The severe tests which every part must undergo indicates the high standard of construction and material insisted upon.

The results which have been attained with these marine turbines prove that the simplification in the machinery involved in the separate shaft units is accompanied with no greater steam consumption than with other turbine systems, even in cruis-



ENGINE ROOM FOR CRUISER, WITH TWO A. E. G. TURBINE SETS OF 12,000 HORSE-POWER EACH, AT 330 REVOLUTIONS

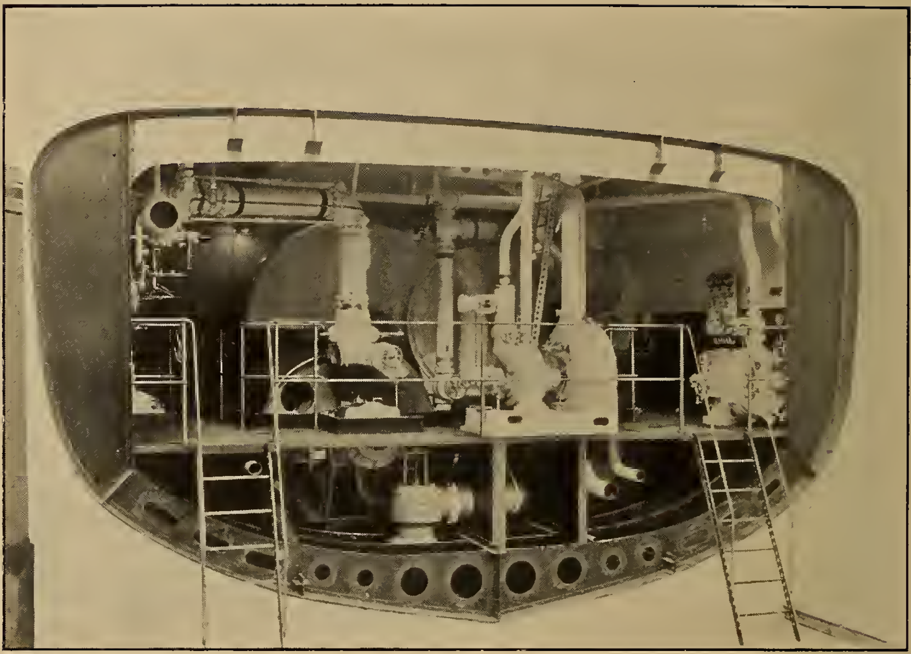


EXHIBIT OF TURBINE MARINE ENGINES AT THE GERMAN MARINE EXPOSITION, SHOWING TURBINE-DRIVEN AUXILIARIES

ing and in short voyages. Similar results will doubtless follow with the *Mainz.* Doubtless the testing department of the A. E. G., fitted with all possible appliances for determining the behaviour of the machinery, has contributed much to the success of the marine steam turbines which have been constructed at this important establishment.

THE RAILWAYS OF BRAZIL

By Lionel Wiener

IV. THE BAHIA INTERMEDIATE SYSTEM

Following out the discussion of the various railway systems of Brazil, commenced in the May issue of this Magazine and continued in the numbers for June and July, Mr. Wiener proceeds to examine the Bahia intermediate system of railways, in which he groups certain land and water routes which have acquired a certain importance as connecting links with the systems to the north and south. —The Editor.

THE Bahia Intermediate System in Brazil extends both along the coast and inland, reaching the Sao Francisco River in several places; it is made up of a number of independent railways and waterways, of which the total has become sufficiently important to warrant the construction of connections with the neighbouring railway systems—with the Great Western in the North, and with the Victoria and Minas in the South.

The gradual grouping of the isolated roads into more powerful groups or companies, in obedience to the economic law of evolution which is so interesting to follow in its development, is here exemplified in two phases. In the North this appears in the working together of the several lines, which is the second stage; in the South, as a recent amalgamation, which is the third stage.

Bahia, the capital of the State, is a town of some importance, being the fourth in size in Brazil, and stands at the head of a bay, where harbour works of considerable magnitude have been undertaken. It is one of the soundest harbours of the east coast, and forms the port for the whole of the State.

The railways around Bahia are laid out in a curious manner. First there is the Timbo and Propria line, running from North to South, a part of which only is open to traffic and the remainder under construction; then there is the Bahia group, and then a gap in the South. The group itself is heterogeneous, and is made up of Northern, Western and Southern lines, radiating from the Bay of Bahia.

The Northern lines are:

	Miles
The Bahia & Sao Francisco Railway and Timbo Branch	129
The Sao Francisco Railway from Alagoinhas to Joazeiro	282

The Western lines:

The Central of Bahia Railway and Branches	198
The Central Western Railway of Bahia	33
The Santa Amaro & Jacu Railway	23

The Southern line:

The Nazareta Tram-Road Company	162

The Northern Railways of Bahia.

The lines of the Northern group work together, the Bahia & Sao Francisco and the Central Railway because they are leased to the same people, Messrs. Lima and Carvalho, and the Sao Francisco Railway because it cannot help it.

The Bahia & Sao Francisco Railway is the most important of the lot; it is the parent line, built to the 5-foot 3-inch gauge, and operated at 67.2 per cent. of the gross earnings. The Timbo branch is a recent addition, from Alagoinhas to Timbo, whence the new line to Propria starts, running further North towards the Great Western System. This branch is worked at a loss; in fact, the ratio of expenses to gross earnings is 137 per cent.

Alagoinhas Junction, whence the Timbo branch starts, is also the

starting point of the Sao Francisco Railway, a long line to Joazeiro, without any branches and operated at a profit.

The Bahia & Sao Francisco Railway will thus have two routes to that river, although itself it runs nowhere near it. In time, however, it may reach the river due west through the Central Railway, since the Sao Francisco River describes a long curve about Bahia as a centre. The Bahia & Sao Francisco Railway was by no means easy to build, and it is the outcome of the old rivalry between Recife and Bahia, both towns wishing to reach the Sao Francisco River. Both lines were started about 1860, but neither has reached the river, there still being a gap, although extensions have been added. There are three tunnels on the main line and a large bridge, 1,790 feet long, composed of a number of 70-foot arches over the Pojuca. This railway carries a large quantity of tobacco, some 4,100 tons, and more than 10,500 tons of wheat and other cereals. The Timbo branch was built in 1887, being constructed to the metre gauge.

The government has taken in hand the further extension of this line and handed the task of building it over to the Railway Study and Construction Committee. A complete survey of the route was made in 1906 by Mr. Greenlagh; the plans were sanctioned in 1907, and the first section has been opened. Two of the long penetration lines now in construction are in the hands of the well-known engineers, Messrs. Greenlagh & Schnoor.

The construction of these long inland lines is a very difficult matter compared to work elsewhere. The first thing to be done is to draw up some kind of a map of the country, which is still almost wholly unexplored, and try to get through somehow. The correct position of Goyaz, the capital, was first astronomically determined by Greenlagh, who showed that most of the maps were from half a degree to a degree in error.

The new line runs from Timbo to Atalaya, on the Great Western System, with a break at the Sao Francisco River, which will be crossed in ferries. The system will be made up as follows:

	Miles
Timbo to Propria, main line	215
Collegio, opposite to Atalaya	94
Simao Dias Branch	62
N. S. das Dores Branch	19
	390

Included in the rolling stock of the Timbo and Propria line is a fine ten-wheel passenger locomotive, built by the American Locomotive Company, weighing 79,500 pounds, and having cylinders 16 × 20 inches, operating at 160 pounds pressure. The boiler has 896 square feet of heating surface, and the fire-box is designed for burning wood exclusively; the tender carrying 2,600 gallons of water and 3½ cords of wood. The equipment of rolling stock is still incomplete, and hence a full account cannot be given.

The Bahia Central Railway is leased by the same company as the Bahia and Sao Francisco, from which it is still separated. These two railways, therefore, are two sections of a system rather than two separate concerns. This road was decreed in January, 1866, and the Paraguassu Steam Train Road Company was floated during the following year to build and operate it. The Province of Bahia subscribed a part of the capital, but notwithstanding this assistance, the company got into difficulties, and the road passed into other hands on September 26, 1872. The Province of Bahia granted a guarantee of 7 per cent. interest to the new company, which was able to proceed with the work of construction, starting from Sao Felix and Cachœira, on opposite banks of the Paraguassu River, at no great distance from the capital.

The first line runs due west to Bandeira de Mello, following the stream all the way, with a short

branch to Olho d'Auga, just before reaching the terminal. The second section runs northward from Cachœira to Feira Santa Anna, passing two miles from Sao Gencalo, and being connected to it by a short branch. The banks of the Paraguassu River are very steep, and the first section from the river to the neighbouring heights was a very difficult one along both lines. A grade of 1 in 30, slightly heavier than the usual one of 1 in 33, was used on this portion to overcome the following banks:

	Distance miles	Elevation feet
Sao Felix Cachœira (west sec.)	3	400
Cachœira to Belem (north sec.)	5	510
Belem to Serra (north sec.)	2½	165

The northern line was built in 1876; the western one later, in 1881, to Serra Grande, and continued in successive sections. The company is undertaking important extensions to both sections: one to join the Sao Francisco at Alagoinhas, the other penetrating deeper into the hinterland. The surveys have been approved by the government, and the work is well in hand; it will add 190 miles, thus doubling the length of the system.

On this line the average distance traveled is only 28 miles for each passenger, as against 91 miles on the Sao Francisco Railway, but there is every reason to believe that this will improve as the line is lengthened.

Both companies pay a tax to the government, besides 10 per cent. of the gross earnings and 20 per cent. of the net earnings. The Central Railway of Bahia has recently been bought back, with the idea of forming it into a system with some other lines, but the State has thus far retained it, with Messrs. Lima and Carvalho as temporary lessees, who are operating it at 75 per cent. of the gross earnings. This is the only line in Brazil with the 3-foot 6-inch gauge, and it is bound to be converted to the metre gauge as soon as connection with any other line is opened up. Such connection has not yet taken place, because both the Central of Bahia and the Nazareth Tram-Road Company have been stopped by the cliffs near the coast. As a matter of fact, the Centre West of Bahia Railway runs from the neighbourhood of the capital westward, skirting the bay to Bom Jardin (34 miles); and the Jacu and Santa Amaro Railway (23 miles) reaches Santa Amaro. But there is still a gap of 25 miles to Cachœira, with the cliffs to be overcome.

The splitting up of the line between so many companies is partly responsible for the existing situation, because such small concerns have lacked either the power or the capital to build the last link.

The company is dependent for its earnings mainly upon the tobacco crop, the Bahia region producing tobacco in large quantities. In 1907 the Central of Bahia Railway carried no less than 12,479 tons of the weed, this forming more than one-third of the total tonnage. The balance consisted principally of aguardente, coffee, xarque (a special kind of dried meat), cereals and salt in about equal proportions of two or three thousand tons. The goods traffic contributed about 77 per cent. of the gross earnings. Although the lion's share of the tobacco crop is carried by the Bahia Central Railway, the neighbouring railways secure a considerable portion of it, the Bahia and Sao Francisco carrying more than four thousand tons.

The greater part of the rolling stock was made in England, this including nearly all of the locomotives, of which the company owns 22, together with 60 out of the 63 coaches. In addition the company owns 8 vans and 492 wagons, of which two-thirds came from the United States and the remainder from Belgium.

The Victoria and Minas Railway.

The Victoria and Minas Company comprises two separate undertakings—the Victoria and Diamantina

Railway, a western penetration line, and the South of Bahia Railway, an interesting connecting line running parallel to the coast for a considerable distance. As along the north coast, there are a number of inward means of communication, these running due west, in a direction at right angles to the coast.

South of Bahia, there is first the small port of Ilheos, whence a railway starts, aiming to reach Conquisto, and now having 31 miles open. Then comes the town of Caraveiras, where two important navigable rivers meet—one, the Rio Pardo, navigable up to the town of that name, and the other the Rio Jequetihenha, navigable up to Arassuahy.

Porto Axeia, on the coast, comes next, this being connected with Theophile Ottoni by the Bahia and Minas Railway, 235 miles in length; and lastly comes Lenhares, near the mouth of the Rio Doce, connected by boat with Figueira and Derubbedinia up-stream, where the new line will pass.

It was the intention of the government to connect the inland termini of these railways and river lines, linking up the Central Railway of Brazil with the South through Derubbedinia, and Theophile Ottoni with Jecquie and the Bahia system in the North. This line is similar to the St. Luiz, Caxias and Great Western Railway, in the Northern States, but it is longer and more useful. It has been incorporated with the Victoria and Minas Company, who have had it thoroughly surveyed by Dr. Schnorr, whom we have already mentioned as a leading engineer.

The line would work out as follows:

	Miles
Jecquie to Conquista (terminal of the Ilheos & Conquista)	137
Conquista to Fortalezza	144
Fortalezza to Arassuahy	130
Arassuahy to Theophile Ottoni (Bahia & Minas Terminal)	117
Theophile Ottoni to Derubbedinia (Victoria & Minas Junct.)	129
	657

The probable traffic has been computed as follows: The estimated population along the line is about 300,000. The local passenger traffic is estimated at 10 per cent. of this, or, say, 30,000 passengers, or at 3,809,375 passenger miles, yielding £26,666 (at 70 reis per kilometre). Goods traffic is estimated at 45,000 tons, or 5,631,250 ton-miles, bringing in £112,265 (at 200 reis per ton-kilometre). Adding through night trains from Rio to Bahia, say 150 trains in the year, at £250 each, or £37,500, besides £9,375 for luggage, the total would be:

		Per Mile
Passengers (local)	£26,666	£41
Goods	112,635	172½
Luggage	9,375	14½
Through trains	37,500	57½
	£186,166	£285

This would compare as follows with the other Bahia lines:

	Receipts per mile	Expenses per mile
Bahia & Sao Francisco	£851½	£687
Timbo Branch	125	187
Sao Francisco Railway	254	237
Central of Bahia	299	238
Nazareth Maine Line	476	367

Taking the expenses at £250 per mile, this would leave a bonus of £21,875 a year.

I have quoted this way of ascertaining the probable working expenses and receipts of a new line, because it is an interesting example of how these items are computed in Brazil. Capital from other countries is called upon to a considerable extent to furnish funds for a number of Brazilian undertakings, and hence the above example may be of some use. It will be interesting to see the extent to which these predictions will be fulfilled.

The trains from Rio to Bahia would run over the company's own tracks to Jecquie, whence they would continue over the line of the Nazareth Tram-Road Company's line to Nazareth, not far from Bahia. This latter line, originally a tram-road, is now a regular railway line, in the hands of a British company, holding a stadoal lease. It starts from Nazareth, on the cliffs bordering the Bay of Bahia, and runs southward to Jecquie, a distance of 162 miles

through Sao Igniez. There is a branch to Areia, where the line forms a complete loop, entering the town by the north and leaving it by the south, this being 18 miles long. As an extension of the Rio line the Nazareth Tram-Road may become of considerable importance.

The other line of the Victoria and Minas Railway, known as the Victoria and Diamantina Railway, is open to traffic for a considerable distance, and is still being constructed beyond. It starts from Victoria Harbour. the capital of the small State of Espirito Santo, and runs to Natividade, on the Minas frontier at the point where it is crossed by the Rio Doce, a distance of 130 miles. This stretch was probably the most costly to build in the country owing to the large amount of heavy earthwork required; the expenditure reached £7,241 per mile. The State having guaranteed £121,513, the liabilities in 1907 amounted to £113,304. This portion was worked at a loss, the expense reaching 116 per cent. of the earnings in 1907, but the situation is daily improving with the opening of new sections.

The line follows the river to Derubbedinia (216 miles), its present terminal, and there crosses it on a bridge 660 feet in length. Construction work is in hand for a considerable distance beyond, and the whole line is surveyed. Before the completion of the line a concession has already been given for an extension from Diamantina to Curralinho, a station on the main line of the Central of Brazil Railway. The Victoria and Diamantina will thus own a line running from the coast westward for a considerable distance inland, with the advantage of having railway connections at both extremities.

One of the interesting features about this line is that it will enable the exportation of large quantities of iron ore, of which there is an almost unlimited supply between the Candonga Serra (238 miles), and Itabira de Matto Dentro. The Brazilian estimates speak of billions of tons, and in any case there is certainly an enormous amount of the very highest grade of ore here available. I have already called attention to the extent to which Brazil, especially the newer States, offers a field for foreign enterprise, especially for railway material and the opening up of these large deposits of iron ore should influence the situation very materially, both in the export of the ore and in the development of the iron manufacturing industry in Brazil itself.

The growth of such industries should enable the country gradually to discontinue the importation of locomotives and machinery as well as of structural steel. The new contract of the Diamantina Railway with the government, December 20, 1909, stipulates the reversion of its lines to the government after 90 years, but grants the company a number of privileges in exchange, with a view to the development of the deposits of iron ore.

The company intends the exportation of between two and three million tons of iron ore annually, and as it fears that even with the use of Mallet locomotives weighing 60 tons, having 30,000 pounds tractive power and hauling 400-ton trains, it will be unable to cope with this heavy traffic, it has decided upon the complete electrification of its lines, an undertaking which must be completed within three years of the signing of the contract.

A branch to Itabira de Matte Dentro will be built immediately into the heart of the iron ore district. This is but a short distance from Santa Barbara, where connection with the branch of the Central Railway of Brazil may easily be made. This branch will leave the main line at Santa Anna de Ferros.

Iron ore will pay the exceedingly low rate of 0.193*d*. per ton-mile The company has undertaken to establish immediately an iron works

having a minimum capacity of 12,000 tons per annum. This is no idle clause, the railway having already closed contracts with an English company for running the works, besides having a number of ships on order for carrying the ore to Europe. This is an example which England may well follow by shipping iron ore from Central India, particularly from the Sandur State, near Mysore, where large deposits of excellent iron ore lie undeveloped.

The Victoria and Diamantina Company's original capital was £1,587,-302 (40,000,000 francs), besides £3,-174,604 debentures. Another £595,-238 debentures have been issued for biulding the Curralinho extension. The State has guaranteed 6 per cent. interest (gold) up to a maximum expenditure of £1,006 per mile (30 contos per kilometre).

This railway will thus be not only the first electric railway in South America, but it will also be one of the first long-distance lines with mixed traffic to make use of electric traction exclusively.

(*To be continued.*)

THE PURCHASING OF MATERIAL

By L. S. Randolph

THE problem of purchasing material naturally separates itself into three divisions: first, the quantity; second, the quality; third, the price. These three are inter-related in a very complex manner, so complex in fact that the problem of purchasing the required material for the least amount of money is beyond the domain of accurate analysis and has passed into that wide, indefinite *terra incognita* of good judgment sometimes profanely called guess-work.

The considerations affecting the resolution of the problem which are involved in the question of quantity are:

1st. The loss on large amounts of stock or stock carried for a long time, caused by the loss of interest, the depreciation and insurance (depreciation including the item of obsolesence on money invested).

2d. The saving, in the lower price quoted universally for large orders, the lower freight rates obtained on large shipments and the monetary value of the promptness with which orders can be filled from large stock.

These two items must be balanced, the one against the other, so as to bring about the minimum expenditure. When money is plentiful the problem can be solved with quite remarkable accuracy.

When money is not plentiful large rates of interest, which are difficult to determine, must be paid. The loss due to high interest charge makes the economically carried stock account small.

It will be readily seen that the problem with which our investigation starts admits of no general solution, but is dependent upon the peculiar conditions surrounding each establishment and under which each establishment is operated.

The modern method of stock keeping gives such accurate control of the amounts of stock and orders that it is almost indispensable for the accurate solution of the above problem and should be used whenever possible.

In brief this method is as follows:

Each item of stock is listed on a card of an index and on a similar card on the bin, giving: the item, size, grade, minimum stock to be carried, maximum stock to be carried and amount of order to be placed when the minimum stock amount has been reached. The amount of the order is usually the difference between the minimum and maximum stock requirements.

The demand for stock may be:

1st. Small and certain but at infrequent intervals. 2nd. Uniformly constant demand as when the continuous process of manufacture requires a continuous supply of material. 3rd. Large but uncertain demand as where material is kept on hand to supply sudden calls for repairs and renewals.

The first and last of the above are those which are more difficult to handle. In the majority of cases the tendency is to carry special stocks too long and to have them too large. In the last case particularly large stocks are only justified by keeping up the good name of a house or where the loss of revenue from a shut down is considerable.

The next item in our problem is the kind and quality of the material to be purchased.

The quality of a material may be defined as those peculiarities, characteristics or properties which fit it for the work which it has to perform; or having which it is identified as a material suitable for the work in hand. When we say good quality we mean that the peculiar properties are such as to fit it in an eminent degree for the work it has to perform.

It should be understood that the properties which we observe are not always those which are valuable or necessary, but those which can be used to identify the material which has those properties which are valuable.

For example, it matters little what the specific gravity of lubricating oil is, except that an oil with a certain specific gravity has one of the elements which identify it as being an oil with the lubricating properties we desire. The same thing may be said of color, taste and smell. In fact, in the case of lubricating oil the properties of the coefficient of friction and durability in service are not susceptible of sufficiently accurate observation to be used, but we rely on those other properties which are used to identify the oil as one having the coefficient of friction and durability we desire. The freezing point of an oil, like the ultimate tensile strength of steel, is a direct measure of one element of its usefulness.

The quality of the material, then, must be such as will do the work required of it at the least cost. We might state this differently and say that quality is the best which gives the largest results for the least cost; as the greatest resilience of a bar of iron or steel for the least amount of money.

In determining the value of a lubricant, the sum of the cost of the lubricant used, the cost of the material worn from the journal and brass and the cost of the power required to overcome the friction gives us the measure of the value of the lubricant. Careful experiment will show that the cost per gallon is a very secondary matter. The tendency to heat should also be included where that is likely to occur, as on railroad trains.

One of the most important points in the purchase of material, the one most frequently neglected and least understood, is that the price per unit is usually the least important factor in determining the value of a commodity.

Under the head of material there must be considered:

1st. The kind of material.

2nd. The quality of material.

Material is at the present time almost always purchased under written specifications. It matters not, however, whether the specifications are written or not; the principle is the same, as a specification is merely a statement of what it is desired to purchase and will be accepted.

In the draughting of a specification or the determining of the material to be purchased the following principal consideration is involved:

The cost of the material should be a minimum for the work to be performed, or that which will produce a minimum of expenditure.

In order to obtain this result careful investigation must be made as to the cost of the different qualities of material, in order to determine the maximum quality for a minimum cost.

Thus the cost of bar iron on one occasion varied with the quality as follows:

Tensile strength.	Elongation, per cent.	Cost per pound, cents.
48,000 lbs	18	1.4
50,000 "	18	1.5
52,000 "	18	2.4

In the last case we get 4 per cent. greater strength over the second case at a cost of 60 per cent. more. We get 4 per cent. more strength in the second case over the first at a cost of 7 per cent. It is manifest that unless the question of weight is of more importance than usual, the last case is not justified. Where, as in steamships or battleships, weight is of

enormous importance, it may be justifiable.

This principle runs through all class of specifications, and in fact is the basis upon which all accurate decisions of the proper kind and quality of material to buy must rest.

Chordal, in one of his letters, says: "Never put a crocus finish on a hand-car crank."

We may briefly state the principle governing the draughting of a specification as follows:

Require only those properties or peculiarities which can be clearly shown to be justified by the price to be paid and the value of the work to be done.

Omit all requirements which have not a definite object and value. They only hamper the manufacturer and are usually not observed a short time after the specification has been issued, while the element of uncertainty in them causes an increase in the cost.

Maximum and minimum limits should invariably be specified and these should be as wide apart as possible. It should be always stated whether these are merely desired limits or limits of rejection.

Uncertainty and indefiniteness are the most expensive things about the average specifications. The manufacturer, being in doubt, must perforce take the most expensive construction which can legally be put on the specification or he runs a risk of loss, and to save himself must increase the price accordingly.

The problem of the price is not susceptible of analysis by any present methods. Of course the best price should be obtained. The lowest of a number of different prices is seldom if ever the best. If all parties quoting are of good reputation it may be, but where this is not the case the lowest price is too often from one who counts on getting in his indifferent goods by chicanery or fraud. Even if he is honest, the improbability of his goods being accepted, promptly shipped or properly directed is very great and the consequent loss more than offsets the saving in price.

The fluctuation in prices are very great at times, varying with the season and the variation of supply and demand. When these fluctuations can be foreseen enormous savings can be made. The president of a railroad placed an order one summer for rails for next summer delivery. By the next summer prices had advanced to such an extent that he sold his old rails for enough to pay for the new ones and $200,000 over.

The petty bargainer and the man who is ever ready to cut prices are the ones to be avoided by the careful purchaser.

THE BALANCING OF RECIPROCATING ENGINES

By R. J. Grimshaw

If a perfectly balanced engine were placed on springs, we should get no motion at all of the springs, but unfortunately, most engines are inadequately or improperly balanced and considerable shock takes place which must be absorbed by the bearers. In the case of reciprocating marine engines, the shock due to imperfect balance must be absorbed by the structure of the vessel, requiring heavy engine bearers and also possibly producing excessive vibration. This may be greatly reduced or altogether eliminated if proper attention be paid in the first place to the matter of balancing in the design of the engine.

Some makers balance their engines by the tentative process of placing weights on the moving parts and varying these in magnitude and distribution until some sort of a balance is obtained. This trial-and-error method usually leads to a heavier engine than would be obtained by proceeding on some scientific line. It is the purpose of this article to show how the various types of reciprocating engines may be balanced.

In a reciprocating engine the moving parts may generally be divided into:

1. Rotating;

and 2. Reciprocating.

The usual practice is to balance rotating masses by rotating masses and reciprocating by reciprocating masses.

THE BALANCING OF ROTATING MASSES

Case 1. *When the Masses All Act in One Plane.*

We will assume that we have a number of masses all acting at a common radius from the axis of the shaft, as shown in Fig. 1. (Whatever the masses and their distances from the axis of the shaft be, we can reduce them to a common radius, since any mass acting as a radius r is equal to a mass $\frac{m.r.}{r_0}$ acting at a radius r.

Suppose then that the masses revolve at an angular velocity ω in the plane LM at a common radius r_0. The effect of each mass is a centrifugal force acting outwards from the same point in the axis. Hence the masses reduce to a single resultant force, acting through this point. Referring the masses to rectangular axes OX, OY moving with the shaft, we have that total force in the direction OX:

$$\begin{aligned}
&= \omega^2 \, (m_1 r_0 \, cos\theta_1 + m_2 r_0 \, cos\theta_2 + m_3 r_0 \, cos\theta_3 + etc.) \\
&= \Sigma \, m_1 r_0 \, \omega^2 \, cos\theta_1 \\
&= \Sigma \, m_1 \, \omega^2 \, x_1 \\
&= \omega^2 \, M . \overline{x}
\end{aligned}$$

in which M is the sum of all the masses and x is the x-coördinate of the centre of gravity of the mass M.

Similarly the total force on the direction $OY = \omega^2 \, M . \overline{y}$. Hence the resultant force $= \omega^2 \, M R$, in which R is the distance of the centre of gravity of the masses from the axis of the shaft.

The effect of these rotating masses

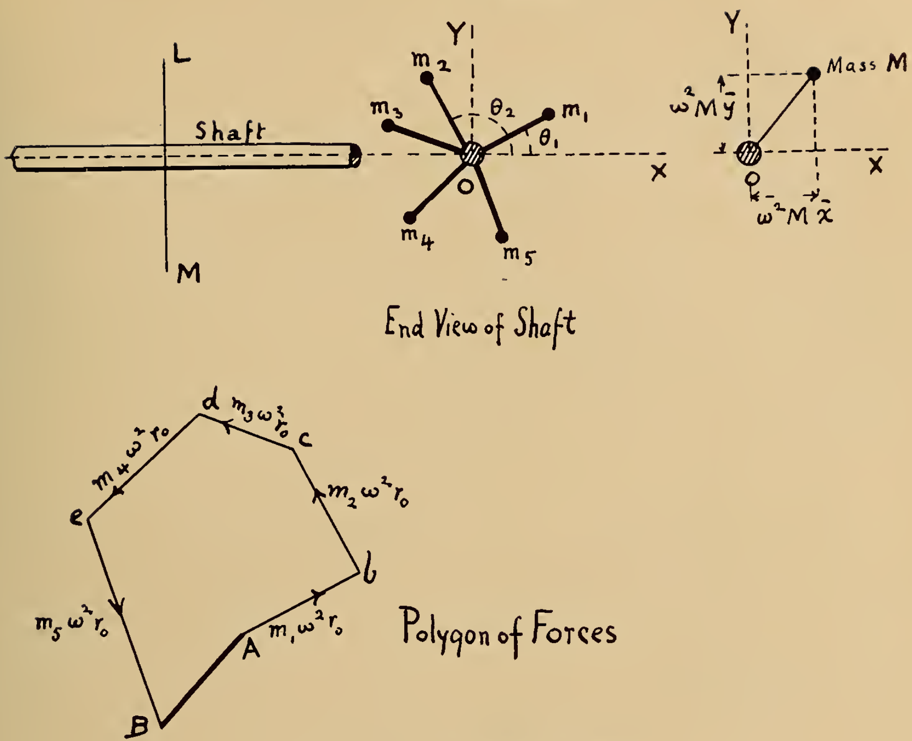


FIG. 1.—BALANCING OF ROTATING MASSES

is therefore the same as if the sum of the masses were concentrated at the centre of gravity of the different masses.

If the centre of gravity is the axis there is no resultant force and the masses then balance.

When the centre of gravity does not lie in the axis of the shaft we can use the polygon of forces to determine the balance weight we must use and its position relative to the other masses.

Draw A b parallel and equal to $m_1 \omega^2 r_0$; b c parallel and equal to $m_2 \omega^2 r_0$;

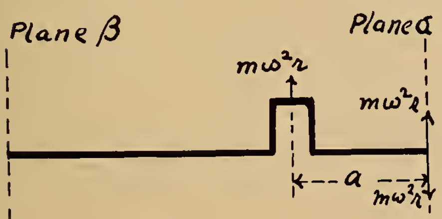


FIG. 2.—SINGLE CRANK

and so on: the closing line B A of the polygon gives the magnitude and direction of the balance mass we must add to the system. If R_1 be the radius at which the balance mass M_1 is to act, then: $M_1 \omega^2 R_1 = B A$ and the direction of the radius must be parallel to B A.

Case 2. *When the Rotating Masses Are Not Co-planar.*

We will refer our forces to a plane of reference α perpendicular to the axis of the shaft, in which the balance masses are to be placed.

Consider the effect of one crank at a distance a from plane α.

The centrifugal force due to a mass m revolving at an angular speed ω and a radius r, is $m \omega^2 r$. In the plane α we can add two equal and opposite forces $m \omega^2 r$ parallel to the force at the crank without affecting the system. The centrifugal force $m \omega^2 r$ at the crank, and the opposite equal force at the axis in the plane α, form a couple $m \omega^2 r . a$. Hence the

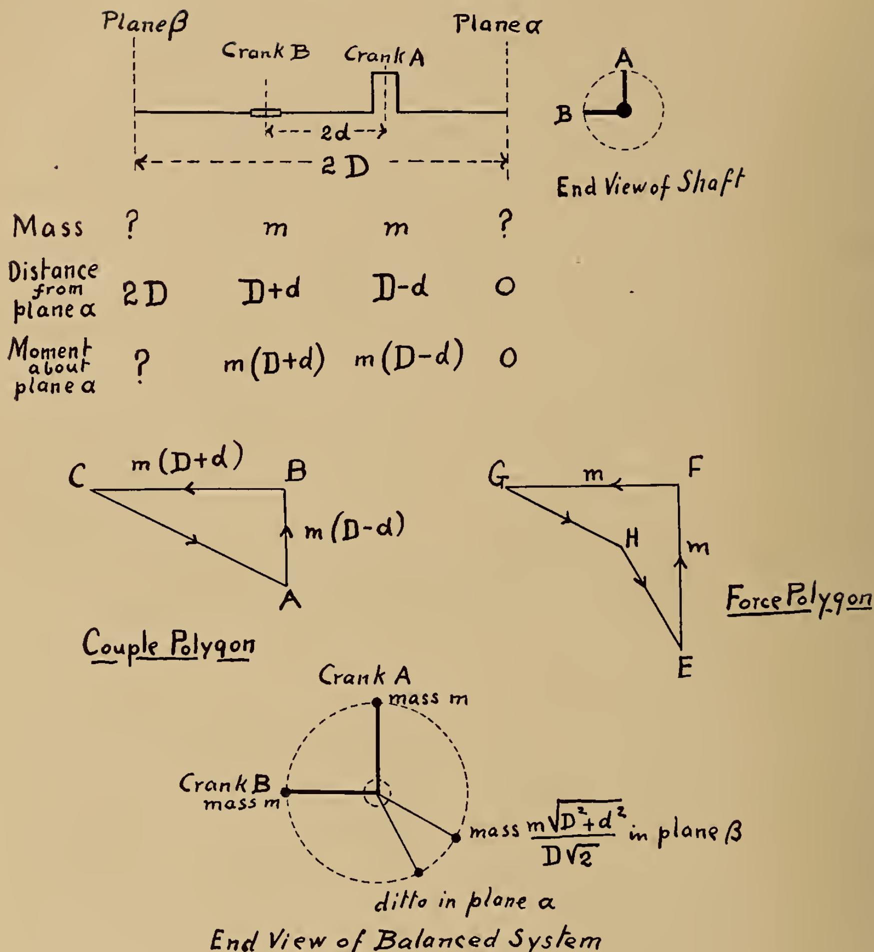


FIG. 3.—DOUBLE CRANKS

effect of the force m ω^2 r at the crank is equal to a couple m ω^2 r.a, and a force m ω^2 r parallel to the force at the crank.

Hence, whatever the number of cranks, it is seen that we can reduce all the centrifugal forces at the cranks to parallel equal forces in the plane α, and couples.

We can compound these separately, and get a resultant force and a resultant couple, and balance these resultants by an opposing equal force and couple, and thus get a perfect balance.

An example will show clearly how this may be done. Suppose, as in a locomotive, we have two cranks at right angles, Fig. 3.

Our planes of reference α and B will be the planes of the driving wheels.

Suppose the magnitude of the rotating masses be m, their distance apart be 2 d, and the spread of the driving wheels be 2 D. For a balance the couple polygon must close, and so must the force polygon. In other words, there must be:

1. No resultant force;
2. No resultant couple.

The state of affairs will be as shown in Fig. 3. In drawing the couple polygon it is more convenient

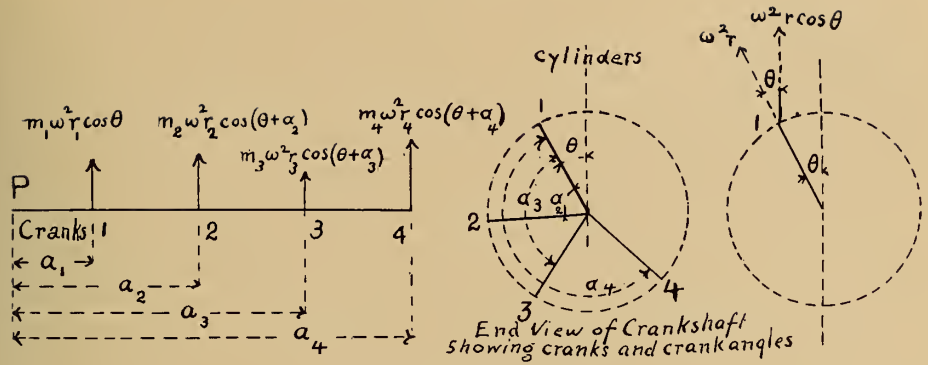


FIG. 4.—FOUR-CRANK ENGINE

to draw the line representing a couple in the plane of the couple, and not, as is usual, perpendicular to that plane.

Take moments about the plane α.

Draw $AB = m\ (D - d)$ and parallel to direction of crank A.

Draw BC equal and parallel to $m\ (D - d)$.

Then will CA represent the balancing couple in magnitude and direction.

$$CA = m \sqrt{2}\ \sqrt{D^2+d^2}$$

Therefore the mass in plane

$$\beta = \frac{CA}{2D} = \frac{m\sqrt{D^2+d^2}}{D\sqrt{2}}$$

To find the balance mass in plane .

We have now three forces of which the magnitude and direction are known, therefore the remaining force is also known in magnitude and direction, since the force polygon must close.

Draw $EF = m$ and parallel to crank A

" $FG = m$ and parallel to crank B

" $GH = m\ \sqrt{D^2+d^2}$

" $GH = \frac{\ }{\sqrt{2}} \cdot \frac{\ }{D}$ and parallel to CA

Then H E, the closing line of the force polygon, equals in magnitude and direction the closing balance force in the plane

Its magnitude is obviously $\frac{m}{\sqrt{2}} \cdot \frac{\sqrt{D^2+d^2}}{D}$

THE BALANCING OF RECIPROCATING MASSES

Along any fixed axis the motion of the projection of each of the rotating masses is harmonic, so that if, instead of being concentrated at and revolving with the crank pin, we have them merely reciprocating harmonically along parallel lines in the same plane, we still get the same forces as before, in the line of the stroke. So, confining ourselves to the line of stroke, the conditions of balance for reciprocating masses are identical with those for rotating masses. That is, there must be:

1. No resultant force;
2. No resultant couple.

In order, therefore, to balance reciprocating masses perfectly, we must use reciprocating masses. Any attempt to balance both rotating and reciprocating masses by purely rotating masses will lead to unbalanced forces and couples perpendicular to the plane of stroke.

Hence, neglecting the obliquity of the connecting rods, we can obtain a

perfect balance by balancing rotating by rotating, and reciprocating by reciprocating.

Neglecting obliquity, let us consider a four-crank engine, Fig. 4. The motion of the reciprocating mass attached to any crank (by means, say, of infinitely long connecting rod) is the harmonic projection of the motion of the end of that crank arm along the line of stroke.

The centrifugal acceleration of the end of the crank arm is ω^2 r, therefore its projection along the line of stroke is ω^2, $r_1 \cos\theta$, for crank No. 1, and $\omega^2 r_2 \cos(\theta+\alpha_2)$ for crank No. 2, etc.

The force in the line of stroke then:

$$= m_1 \omega^2 r_1 \cos\theta + m_2 \omega^2 r_2 \cos(\theta+\alpha_2) + m_3 \omega^2 r_3 \cos(\theta+\alpha_3) + m_4 \omega^2 r_4 \cos(\theta+\alpha_4)$$
$$= \cos\theta \, [m_1 \omega^2 r_1 + m_2 \omega^2 r_2 \cos\alpha_2 + m_3 \omega^2 r_3 \cos\alpha_3 + m_4 \omega^2 r_4 \cos\alpha_4]$$
$$- \sin\theta \, [m_2 \omega^2 r_2 \sin\alpha_2 + m_3 \omega^2 r_3 \sin\alpha_3 + m_4 \omega^2 r_4 \sin\alpha]$$
$$= \cos\theta \, [m_1 \omega^2 r_1 + \Sigma \, (m_2 \omega^2 r_2 \cos\alpha_2)]$$
$$- \sin\theta \, [\Sigma \, (m_2 \omega^2 r_2 \sin\alpha_2)]$$

Also taking moments about any point P in the axis of the shaft we have:

Couple about P in plane of engine:

$$= \Sigma \, m_1 \omega^2 r_1 \cos\theta \times a_1$$
$$= \cos\theta \, [m_1 a_1 \omega^2 r_1 + \Sigma \, (m_2 a_2 \omega^2 r_2 \cos\alpha_2)]$$
$$= \sin\theta \, [\qquad \Sigma \, (m_2 a_2 \omega^2 r_2 \sin\alpha_2)]$$

If the four reciprocating forces are mutually balanced we must satisfy the conditions that:

1. The total couple is zero;
2. The total force is zero,

for all values of the angle θ.

These conditions are satisfied if:

$$m_1 \omega^2 r_1 + \Sigma \, (m_2 \omega^2 r_2 \cos\alpha_2) = 0 \quad \ldots\ldots\ldots\ldots\ldots (1)$$
$$\Sigma \, (m_2 \omega^2 r_2 \sin\alpha) = 0 \quad \ldots\ldots\ldots\ldots\ldots (2)$$
$$m_1 a_1 \omega^2 r_1 + \Sigma \, (m_2 a_2 \omega^2 r_2 \cos\alpha_2) = 0 \quad \ldots\ldots\ldots\ldots (3)$$
$$\Sigma \, (m_2 a_2 \omega^2 r_2 \sin\alpha_2) = 0 \quad \ldots\ldots\ldots\ldots (4)$$

The left-hand side of equation (1) represents the total force parallel to crank arm No. 1. Similarly that of equation (2) represents the total force perpendicular to crank-arm No. 1.

Now if the resolutes of a force in two directions at right angles are each zero, then that force is zero. Hence equations (1) and (2) give the condition that there is no resultant force in the system.

Similarly, equations (3) and (4) give the condition that there is no resultant couple.

For example: Suppose we are given two crank angles, the distance between the cylinders and one mass. The problem is to find the three remaining masses and the angles at which the remaining cranks must be set. See Fig. 5.

Suppose we are given angles C O D and C O B; the distances a_2, and a_3, and a_4; and the mass m_4.

The couple triangle is known, thus:

Draw $a\,b = m_4\,a_4$ and parallel to crank O D; b c parallel to crank O C; a c parallel to crank O B.

The two lines b c and a c meet at c, and hence $b\,c$ = couple $m_3\,a_3$, and $c\,a$ = couple $m_2\,a_2$.

Hence, since a_2 and a_3 are known, so are m_2 and m_3.

We can now proceed to draw the force polygon.

Thus, draw p q parallel and equal to m_4, (m_4 represents the forces m_4 r ω^2, as we are assuming that r and ω^2 are common to all the forces), q r

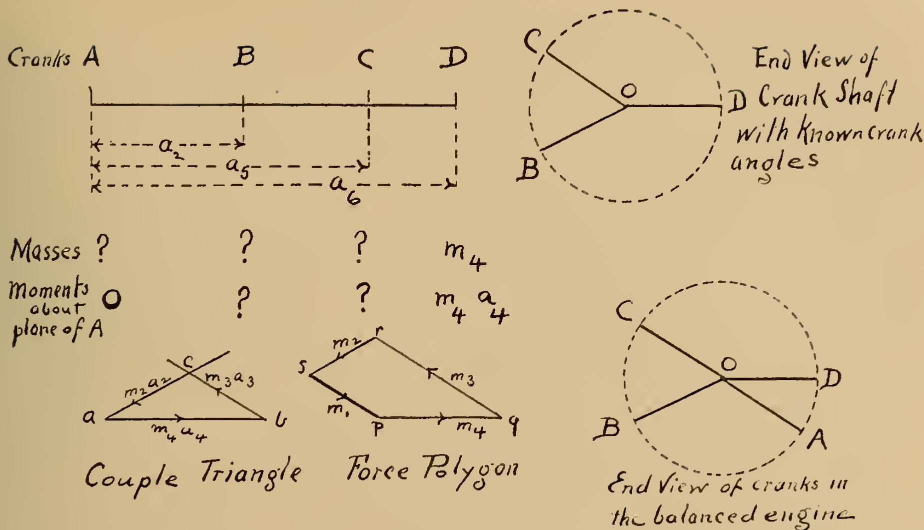


FIG. 5.—FOUR-CYLINDER PROBLEM

parallel and equal to m_3; p s parallel and equal to m_2; then the closing line s r represents in magnitude and direction the balance mass m_1. Hence draw O A parallel to s r; the angle D O A represents the angle at which me must set our crank O A in order to have a balance for reciprocating forces; the line s r representing the magnitude of the remaining mass.

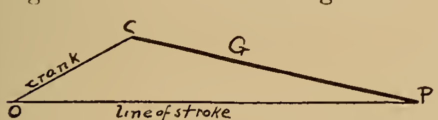


FIG. 6.—ROTATING AND RECIPROCATING PARTS

Certain parts, however, are neither purely reciprocating nor purely rotating. The connecting rod is an example of such. Thus the point C, in the connecting rod C P, rotates, while P reciprocates. If G be the centre of gravity of the rod, then it can be shown that almost the correct effect due to the motion of the rod is given if we assume $\frac{CG}{CP}$ of the mass of the rod to reciprocate at P; and $\frac{PG}{CP}$ of the mass of the rod to rotate at the crank pin C.

In balancing locomotive engines the usual practice is to attempt a part balance by balancing the reciprocating parts with rotating masses applied to the driving wheels. This procedure introduces forces perpendicular to the plane of the cylinders, and the maximum unbalanced force so introduced is termed the "hammer blow." It is the force which is alternately put in and taken off the rims, and gives the driving wheels a tendency to skid.

DATA FOR BALANCING LOCOMOTIVES

Stroke	24	ins.
Distance between cylinders....................	28½	"
Distance between wheels......................	58	"
Radius of balance-weight circle	35	"
Weight of piston..............................	100	lbs.
Weight of piston rod.........................	85	"
Weight of crosshead.........................	55	"
Weight of crank webs (uniform).............	560	"
Weight of crank pin..........................	52	"
Weight of connecting rod....................	450.	"

The following shows how we should proceed to balance a locomotive engine with two cranks at right angles.

The dimensions are given on the preceding page.

The centre of gravity of the connecting rod was distant two-fifths of its length from the crank pin. The shaft made 250 revolutions per minute.

Total weight of reciprocating parts

$= \text{weight of piston} + \text{piston-rod} + \text{cross head} + 2/5 \text{ connecting rod}$
$= 100+85+55+(2/5\times450)=420$ pounds

This must be reduced to an equivalent mass of $\frac{12}{35}\times420$ pounds, because we have to place our balance weight, not in the crank circle of a radius of 12 inches, but in the balance weight circle, of 35 inches radius, which gives 144 pounds.

Total weight of rotating parts

$= \text{weight of crank pin} + \tfrac{1}{2} \text{ crank webs} + 3/5 \text{ connecting rod}$
$= 52+(\tfrac{1}{2}\times560)+(3/5\times450)$
$= 602$ lb. at 12 in. radius
$= 206.4$ lb. at 35 in. radius

To balance reciprocating parts, the state of affairs is shown in Fig. 8.

The couple polygon must close. Hence, drawing a b parallel to crank 1, and equal to $144\times42\tfrac{1}{4}$ pound-inches, to some convenient scale; and b c parallel to crank 2 and equal to $144\times\frac{27\tfrac{1}{2}}{2}$ pound-inches; we have c a represents in magnitude and direction the moment of the balance mass in driving wheel α about plane of driving wheel β.

Hence, scaling off $c\,a=\frac{176}{4}\times144$ lb. ins., we have for the magnitude of balance mass in driving wheel α;

$$\left(\frac{176}{4}\times144\right)\div56=113 \text{ lb.}$$

For reasons of symmetry it is seen that the magnitude of the balance mass in plane β must also be 113 pounds, placed symmetrically with respect to balance mass in plane α. The balance masses in planes α and β are, hence,

$$\frac{206.4}{144}\times113=169 \text{ lb. each,}$$

and with directions identical with those for reciprocating parts. The same result would, of course, follow the closing of the polygon.

To balance rotating parts.

The figures we have already drawn for reciprocating forces answer equally well for rotating forces, the scale only being different. We should replace our masses of 144 pounds with masses of 206.4 pounds. using otherwise the diagrams already given.

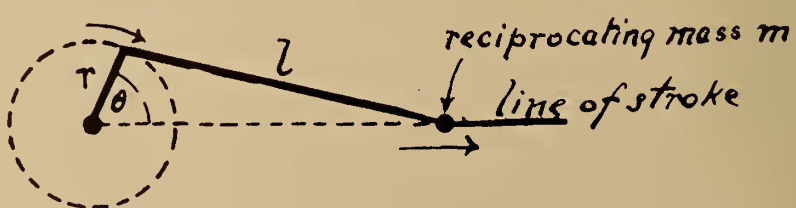


FIG. 7.—OBLIQUITY OF CONNECTING ROD

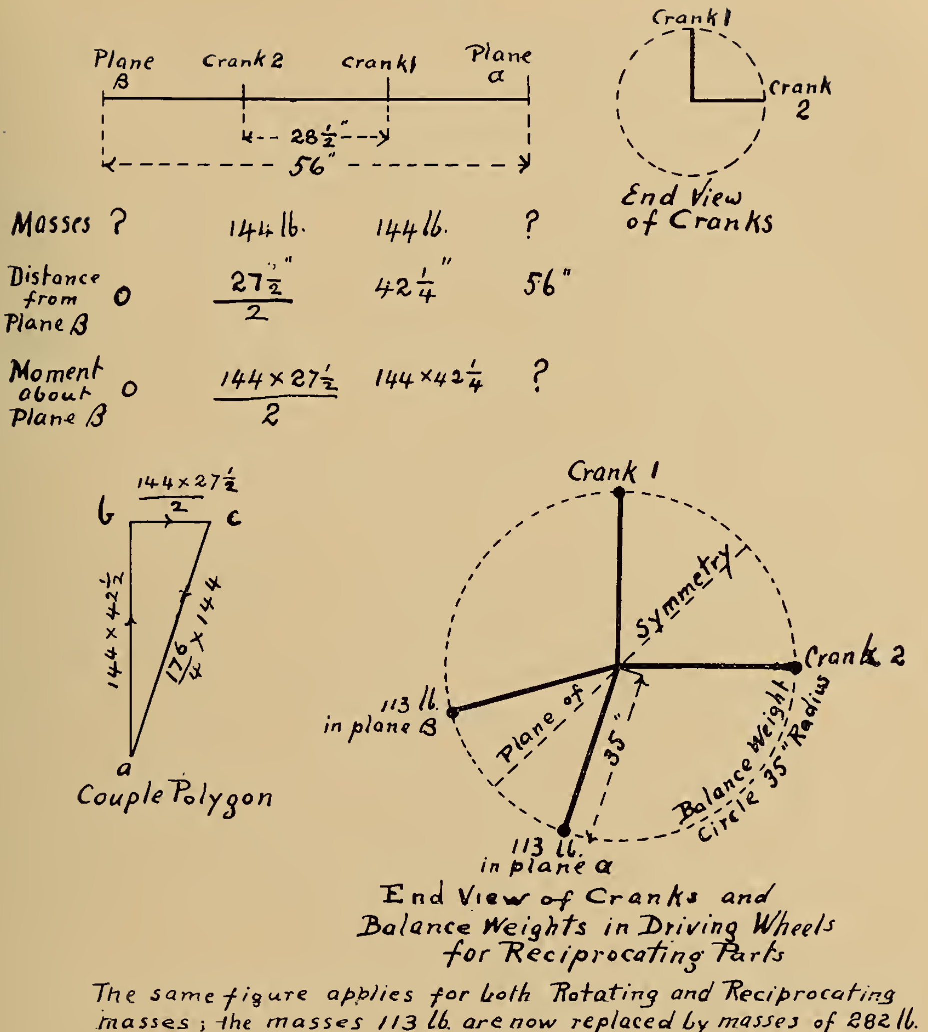


FIG. 8.—BALANCING LOCOMOTIVE ENGINE

To balance both rotating and reciprocating parts.

We have now two sets of balance masses in driving wheels, of 113 and 169 pounds in each wheel. To balance both rotating and reciprocating parts, these balance masses must be compounded. In this particular case this is done simply by adding them.

HAMMER BLOW

We have attempted to balance the reciprocating parts by rotating masses of 113 pounds each, placed in the driving wheels. The centrifugal force due to these is $\frac{113}{g}.\omega^2 r$; in which

$$g = 32.2 \text{ (the acceleration due to gravity)}$$

$$\omega = 250 \text{ revolutions per minute} = \frac{250 \times 2\pi}{60} \text{ per second}$$

$$r = \frac{35}{12} \text{ feet.}$$

Hence the magnitude of the hammer blow at the rims is given by:

$$\frac{113}{32.2}\left(\frac{250}{60}\times 2\pi\right)^2\times\frac{35}{12}\text{ pounds}$$

$= 7{,}000$ pounds.

Hitherto we have not considered the effect of the obliquity of the connecting rod. The motion of the reciprocating masses ceases to be harmonic. If n denote the ratio of length of connecting rod to length of crank arm, then the acceleration of the reciprocating masses at any point of the stroke given by the angle θ of crank to line of stroke may be taken as:

$$r.\omega^2 \left(\cos\theta \times \frac{\cos 2\theta}{n} \right.$$

r being the radius of the crank arm and ω the angular velocity of the crank shaft.

The effect of obliquity is to add a second harmonic of double the frequency to the primary harmonic given by $r\,\omega^2 \cos\theta$.

Considering a four-crank engine with obliquity, but neglecting the effect of the valve gears, the force in the line of stroke due to a reciprocating mass m is:

$$m\,\omega^2\,r \left(\cos\theta + \frac{\cos 2\theta}{n} \right)$$

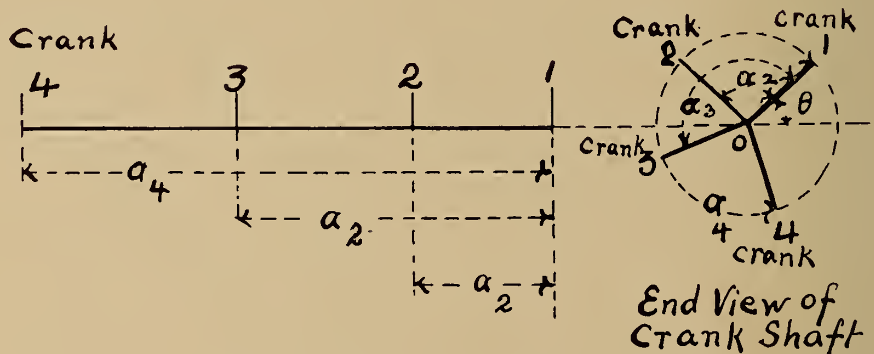


FIG. 9.—BALANCING FOUR CRANKS, WITH OBLIQUITY OF CONNECTING RODS

Hence we have, due to the four cranks, the force in the line of stroke

$$= m_1\, r\, \omega^2 \cos\theta + m_2\, r\, \omega^2 \cos(\theta+\alpha_2) + m_3\, r\, \omega^2 \cos(\theta+\alpha_3)\; m_4\, r\, \omega^2 \cos(\theta+\alpha_4)$$

$$+ \cos\frac{1}{n}\, r\, \omega^2\, [m_1 \cos 2\theta + m_2 \cos 2(\theta+\alpha_2) + m_3 \cos 2(\theta+\alpha_3) + m_4 \cos 2(\theta+\alpha_4)]$$

$$= \cos\theta\, [m_1 + \Sigma m_2 \cos\alpha_2]$$

$$- \sin\theta\, [\quad \Sigma m_2 \sin\alpha_2]$$

$$+ \frac{\cos 2\theta}{n}\, [m_1 + \Sigma m_2 \cos 2\alpha_2]$$

$$- \frac{\sin 2\theta}{n}\, [\quad \Sigma_2 \sin 2\alpha_2]$$

Taking moments about No. 1 (in axis of shaft), total couple in plane of cylinders:

$$=m_4\,\omega^2 r\,cos\,(\theta+\alpha_4)\times a_4+m_3\,\omega^2 r\,cos\,(\theta+\alpha_3)\times a_3+m_2\,\omega^2 r\,cos\,(\theta+\alpha_2)\times a_2$$

$$+\,m_4\,\omega^2 r\,\frac{cos\,2\,(\theta+\alpha_4)}{n}\times a_4+\;.\;.\;.\,m_2\,\omega^2 r\,\frac{cos\,2\,(\theta+\alpha_2)}{n},\times a_2$$

$$=cos\theta\,[\Sigma m_2\,a_2\,cos\alpha_2]$$
$$-\,sin\theta\,[\Sigma m_2\,a_2\,sin\alpha_2]$$
$$+\,\frac{cos\,2\theta}{n}\,[\Sigma m_2\,a_2\,cos\,2\,\alpha_2]$$
$$-\,\frac{sin\,2\theta}{n}\,[\Sigma m_2\,a_2\,sin\,2\,\alpha_2]$$

Now for a balance the total force must be zero and the total couple must be zero. Hence, to satisfy these conditions for any value of θ we must have:

$$m_1+\Sigma m_2\,cos\,\alpha_2 = 0 \quad (1)$$
$$\Sigma m_2\,sin\,\alpha_2 = 0 \quad (2)$$
$$m_1+\Sigma m_2\,cos\,2\,\alpha = 0 \quad (3)$$
$$m_2\,sin\,2\,\alpha_2 = 0 \quad (4)$$
$$\Sigma m_2\,a_2\,cos\alpha_2 = 0 \quad (5)$$
$$\Sigma m_2\,a_2\,sin\alpha_2 = 0 \quad (6)$$
$$\Sigma m_2\,a_2\,cos\,2\,\alpha_2 = 0 \quad (7)$$
$$\Sigma m_2\,a_2\,sin\,2\,\alpha_2 = 0 \quad (8)$$

Equations 1 and 2 refer to primary forces; equations 3 and 4 refer to secondary forces; equations 5 and 6 refer to primary couples; equations 7 and 8 refer to secondary couples.

It is also obvious that the eight equations are quite independent of the number of cranks. The whole eight equations must be satisfied for a perfect balance (neglecting valve gears) of reciprocating parts, whatever the number of cranks.

With four cranks we cannot satisfy the whole eight equations, so we cannot obtain a perfectly balanced four-crank engine. We can, however, so arrange matters that we can satisfy the first six equations, and so balance for everything but the secondary couples.

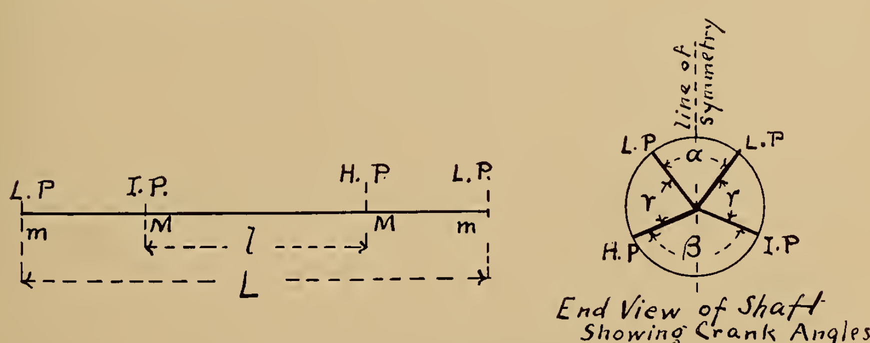


FIG. 10.—YARROW-SCHLICK-TWEEDY SYSTEM

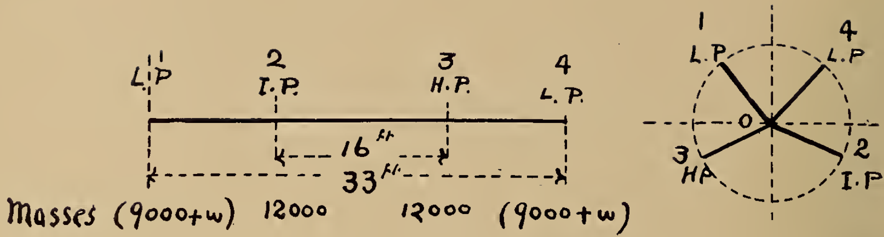


FIG. 11.—BALANCING FOUR-COUPLED ENGINE

This is done in the Yarrow-Schlick-Tweedy system in the following manner:

We can satisfy the first six equations by making (1) the outer masses in the low-pressure planes equal; (2) the inner masses in the intermediate-pressure and high-pressure planes equal; and arranging the position of the cylinders so that the distance between low-pressure and intermediate-pressure cylinders equals the distance between the high-pressure and low-pressure cylinders.

If we denote the low-pressure reciprocating masses by m, and the inner masses by M, and put the ratios:

$$\frac{M}{m} = x$$

and

$$\frac{L}{l} = y$$

Then substituting in the first six equations, we must have:

$$x^2 + \frac{x}{2}(y^2 - 1) - y^2 = 0$$

and $\cos\alpha = x - 1$

$$\cos\frac{\beta}{2} = \frac{1}{x}\cos\frac{\alpha}{2}$$

and the angle between low-pressure

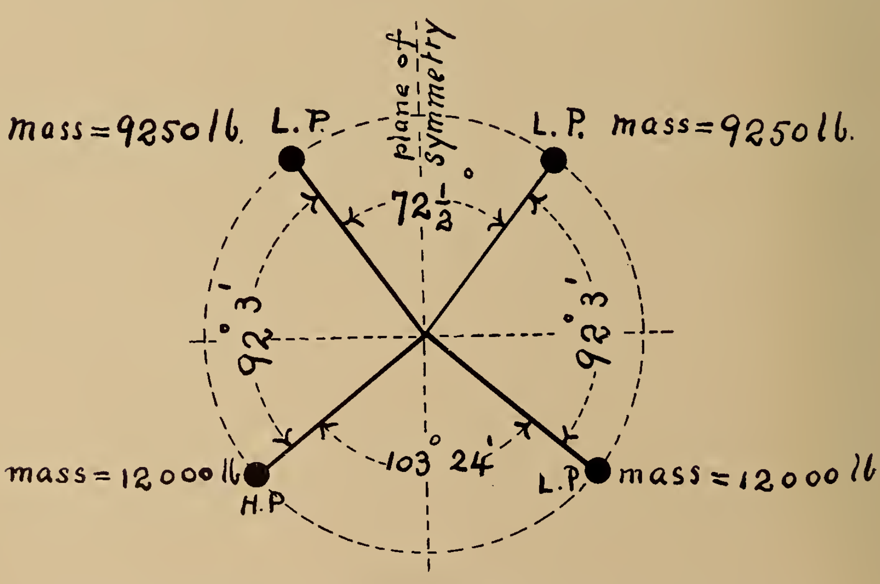


FIG. 12.—END VIEW OF BALANCED CRANK SHAFT, SHOWING CRANK ANGLES

and high-pressure cranks equals the angle between the low-pressure cranks.

α is the angle between the low-pressure cranks.

β is the angle between the high-pressure and intermediate-pressure cranks.

An example of the application of the above equations to the balancing of a four-crank engine is as follows:

The data given are:

placed in the low-pressure planes, then:

$$12{,}000 = x\ (9{,}000 + w)$$

whence $w = 250$ lb.

That is: the reciprocating weights in the low-pressure planes must be increased by 250 pounds.

To find the crank angles.

Cos of crank angle 1-0-4, (see diagram) $x - 1 = 0.3$; hence the angle between the low-pressure cranks = 72½ degrees.

Distance between low-pressure cranks	35 ft.
Distance between high-pressure and intermediate-pressure......	16 ft.

Total reciprocating masses:

For the high-pressure cylinder........................	12,000 lb.
For the intermediate-pressure cylinder	12,000 lb.
For each low-pressure cylinder	9,000 lb.

The relative positions of the cranks along the crank shaft were unalterable, and any additional weights necessary were to be placed in the low-pressure planes.

Here $y = \frac{35}{16}$ and is unalterable.

Hence solve for x in Schlick's equation, making $y = \frac{35}{16}$

$$x^2 + \frac{x}{2}\left\{\left(\frac{35}{16}\right)^2 - 1\right\} - \left(\frac{35}{16}{}^2\right) = 0$$

whence $x = 1.3$ nearly.

If w be the additional weight to be

Also: *cos* crank angle $\frac{2\text{-}0\text{-}3}{2} = \frac{1}{x}$.

cos crank angle $\frac{1\text{-}0\text{-}4}{2} = 0.62$

hence one-half the crank angle 2-0-3 $= 51^\circ\ 42'$, and whole angle between the high-pressure and low-pressure cranks is equal to $103^\circ\ 24'$.

Hence the system is balanced for reciprocating forces if we arrange crank angles and masses as shown in the figure.

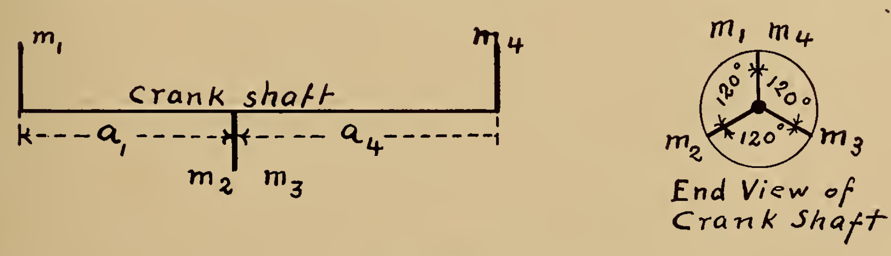


FIG. 13.—THREE-CRANK BALANCING

The rotating masses must be dealt with separately, as indicated previously, the crank angles being fixed by the balance of the reciprocating masses.

We can satisfy the whole of the eight equations by:

(1) Three equal masses in one plane, the cranks being at 120;

(2) By one crank in each of two outer planes and two cranks in a central plane.

In this case the cranks in the outer planes must be parallel to those in the central plane, and make angles of 120 with them and with each other, as shown in Fig. 13.

The sum of the outer masses must be equal to each of the central masses, and the moment of the outer masses about the central plane must be equal.

Here $m_2 = m_3 = m_1 + m_4$

and $m_1 a_1 = m_4 a_4$

We can obtain a 5-crank balanced engine by superimposing two such systems, so that the central masses are co-planar. The latter then reduce to a single resultant mass, and we have a balanced 5-crank engine in which the primary and secondary forces and couples are all balanced with the exception of the valve gears. In the same manner a 6-crank balanced engine could be obtained by combining with the 5-crank system another balanced system so that the central resultant crank mass is zero.

In all the preceding investigations the effect of the valve gears has been neglected. They are usually of very small account, but can be balanced if we represent each crank and its valve gears by an equivalent resultant crank. This is easily done graphically by an obvious process. We then proceed as already indicated for both reciprocating and rotating masses.

THE HORSE-POWER

By H. M. Phillips

"HORSE-POWER" is now a word that is in almost daily use, not only among engineers, but with the world at large; the advent of the automobile, motor boat and aeroplane has done much toward making the expression familiar, yet with the exception of engineers of technical training, there are comparatively few that know exactly what a horse-power is and how it may be measured.

When it is stated that an engine will develop five horse-power a natural comparison conveys a fairly definite idea to the mind, although the critic may inquire what kind of a horse and how hard is he supposed to be working? When we hear of a 20,000 horse-power engine we find it difficult to imagine that number of quadrupeds at work. Why is it that the lightest automobile carries a 15 horsepower engine? Why is the 30-knot torpedo boat having a displacement of only 250 tons and cutting the water like a knife, equipped with 5,000 horse-power engines, while the clumsily built 9-knot freighter, with twenty times the displacement, requires but 1,000?

To the engineer the horse-power is a perfectly definite unit of measurement; as definite as the foot, the pound, or the minute, all of which are combined in the horse-power unit. The horse-power is the unit for measuring the rate at which energy is being expended; the ability to do a certain amount of work in a given time; one horsepower is the amount necessary to raise a weight of 33,000 pounds one foot in one minute. If one pound is raised 33,000 feet, or if any body is moved this distance while offering a resistance of one pound to the moving force, in one minute it will amount to the same thing. Any combination may be taken where the product of the force in pounds by the distance in feet is 33,000 and the time consumed by the operation one minute, as, for example, the belt driving a machine. If two minutes are allowed for the task the amount of *work* accomplished is obviously the same, but the horse-power is reduced to one-half; it is evident that a horse can do more work in two minutes than he can in one, and that if a task is to be accomplished in half the time energy must be expended with twice the rapidity.

Returning to the original quadruped, it will be seen that when walking at three miles per hour he will have to exert a pull of 125 pounds on the traces in order to deliver one horse-power, according to the engineering definition; if he trots at the rate of nine miles per hour one-third of this pull will be sufficient. The writer, weighing 175 pounds, has ascended a flight of stairs 10 ft. 2 in. in height in three seconds, a feat easily accomplished by any man of fair activity. During the three seconds in question the human engine developed nearly one and one-tenth horse-power. Substitute a tread mill for the stairs and this amount of power, less the friction of the mill, could be transmitted to a shaft and used in any manner desired.

Some mechanical operations require a surprisingly large amount of power, while others are performed with much less than the novice might

expect; the secret is usually found in the speed at which the machine runs. The automobile, rated at from 15 to 60 horse-power, will serve as an example. It is heavier than an ordinary carriage, and consequently is harder to pull, even on level ground; on an up-grade, where the weight of the machine is being raised the height of the hill, the difference is much more marked, for no refinement of bearings can reduce the pull due to gravity. The vehicle drawn by a horse seldom exceeds a speed of 10 miles per hour; if that speed were increased to 20 miles, a moderate automobile speed, the power required to draw it would be doubled, even though the actual pull remained the same; as a matter of fact the pull would have to be greatly increased, perhaps doubled, in which case four times the original power would be required. The resistance of the air is trifling at 10 miles per hour, at 20 it becomes serious, and when the speed is increased to 40 miles or more a great deal of power is required to overcome it; an idea of the wind pressure on an automobile may be obtained from that felt on the body when exposed to a gale of wind whose velocity rarely exceeds 40 miles per hour. The increase of resistance with speed is much more marked in water than in air, as illustrated above by the torpedo boat and freighter.

In many of the large machine shops a huge engine lathe may be seen; it is 10 ft. high and covers a floor space of 10 x 30 ft.; a group of heavy steel gears is required to transmit the power for the work being done. A steel casting 5 ft. in diameter and weighing 25 tons is being rotated between the lathe centers while its surface is being turned. A shaving comes in a spiral from the point of the cutting tool, a steel shaving ¾ of an inch wide and 1/16 of an inch thick, the heat developed in tearing the shaving from the body of the casting is so great it is colored a deep blue, a sign that is very nearly red hot when torn off. The ponderous machinery trembles with the strain. Fifteen or 20 horse-power may be required to drive this lathe, the speed at which it is turning being comparatively low. In another part of the shop we may find a man polishing small pieces of brass on a "buff wheel"; the wheel itself is 18 inches in diameter and is composed of round pieces of soft cloth, having no support except at their center, where they are secured to a light shaft. When stationary the wheel will not keep its shape, but when the shaft is driven by a light belt at a speed of 2,500 revolutions per minute, the wheel becomes quite rigid. The entire machine may be about four feet in height and occupy a floor space three feet square. The operator presses a piece of "rouge" against the circumference of the revolving wheel to give it the desired polishing property, then holding the brass with any suitable instrument, he presses it forcibly against the wheel. The friction tends to carry the work around with the revolving wheel, but is prevented from doing so either by the strength of the operator or by allowing the work to rest on a stationary shelf which just clears the wheel. This force, we will say, exerts a pull of 50 pounds at the circumference of the wheel, which travels at the rate of 11,780 ft. per minute; multiplying these two together and dividing by 33,000, we find that the wheel is consuming 18 horse-power in addition to the friction of the shaft, approximately the same amount of power required for the giant lathe. This amount of power can be applied continuously for a few seconds only; the wheel is sometimes ignited by the heat generated by the friction.

The power required to operate an elevator is a simple problem; so many pounds to be lifted at a given number of feet per minute will represent about 60 per cent. of the power required, the remainder being

lost in friction. When counter-weights are used only the unbalanced load is considered. Pumping water to a given elevation is practically the same thing; a cubic foot weighs about 62½ pounds, knowing the number of cubic feet per minute required and the distance it is to be lifted, the horse-power can be figured that is expended in lifting the water; to this must be added a certain amount for friction in the pipes and in the pump. If the pump is to deliver water against a definite pressure the equivalent lift may be found, a pressure of one pound per square inch being equal to a "head" or lift of 2 3/10 feet; or we may figure how fast a column of water one square inch in section must travel to deliver the required amount, which, multiplied by the pressure in pounds per square inch and divided by 33,000, will give the required horse-power, exclusive of the friction of the pump.

The amount of power obtainable from a stream can be calculated in a similar manner; measurements of the channel and the velocity of the stream will give the number of cubic feet, readily reduced to pounds, of water flowing per minute; with a given amount of fall the power in the water may be calculated, it is the same that would be required to raise it the same height by a pump, no allowance being made for friction. From 60 to 90 per cent. of this power may be delivered for commercial purposes by a water-wheel or turbine.

The buffing wheel previously described suggests an easy method of measuring the power that can be delivered to a revolving shaft from any source. A brake is applied to the revolving shaft until the desired load is obtained, the power is then calculated from the pull exerted on the brake and the speed of the shaft. The brake may be made in a variety of forms, the general idea being always the same. The details will vary with the amount of power to be measured, the speed of the shaft and the available material. A cord or rope may be given one or more turns about the circumference of a pulley or fly-wheel and tension applied by means of a spring balance attached to each end. If the pulley exerts no pull upon the rope, both balances will read the same, but the friction of the revolving pulley does exert a pull which is measured by the difference between the readings, the velocity of the circumference of the pulley in feet per minute may be obtained by counting the revolutions and the horse-power found by dividing the product of pull and velocity by 33,000. Weights of any kind may be substituted for one of the balances. One reading only is then necessary in order to make a measurement, for the fixed weight may be determined before or after the test. A band may be carried around the wheel and tightened by means of a screw. In order to prevent the band from turning it is attached to an arm of any convenient length, the end of which rests upon a platform scale, the point from which the arm exerts its downward pressure on the scales should be on the same level as the center of the shaft in order to prevent a lateral pressure, which would not be recorded by the scales. In this case the arm acts as a lever and the weight recorded is less than the actual pull at the circumference of the pulley. This leverage could be measured, but it is unnecessary to do so, for if we consider the pulley to have a radius equal to the distance from the center of the shaft to the point where the arm exerts its downward pressure the same result will be obtained. The power may then be calculated as in the preceding case. If the scales support a part of the weight of the arm independently of any pressure exerted by the friction of the brake, this weight must be deducted from the reading of the scales. The results obtained with these brakes are as accurate as

the measurements of distance, speed and weight from which they are calculated. The weight is sometimes difficult to obtain with accuracy, as it is likely to vary so rapildy that an exact reading is difficult to obtain. Lubrication of the friction surfaces tends to steady the load, and with properly constructed apparatus the total error should not exceed one per cent. of the power being measured.

The friction of the brake causes it to heat rapidly, and although the temperature reached will depend upon the size and form of the break as well as upon the power absorbed, it is safe to say that if more than five horse-power is to be measured it will be necessary to provide some means of cooling if the brake is to be used for more than a few minutes. Brake pulleys are frequently made with a flange at each edge, extending toward the center; water is then led to the inside of the rim by a pipe; while the pulley is revolving it will be held to the rim by centrifugal force and retained within the pulley by the flanges. A drain pipe may be so arranged that it will scoop some of the water from the revolving pulley as the depth inside the rim becomes too great; in this way a constant circulation of cold water may be obtained. Very powerful brakes for high-speed shafts are made in which the friction is produced by a violent churning of water instead of by pressure between solid surfaces; a brake the size of a barrel may be made to absorb several thousand horse-power, while in operation it is surrounded by a cloud of steam.

Brake methods are very useful in determining the power that an engine or machine of any kind can deliver, but they fail to answer the important question of how much power will be required for a given purpose, to drive a single machine of any kind, to light a building by electricity or to run a factory. Neither will they show how much power is being used for any of these purposes at a given time. In a few cases (elevators, pumps, etc.) the power required for an individual machine may be estimated with considerable accuracy from the work that is to be performed. In the majority of cases a fairly close estimate can be made by an experienced engineer, who combines his own good judgment with his knowledge of results obtained from tests on similar machines. The power to be supplied for a factory is determined in much the same way; a part can be quite closely calculated, but the total is a matter of judgment and experience.

It is, however, possible to measure the power consumed by a machine in actual operation with considerable accuracy. When electrical power is available the machine to be tested may be driven by a motor by the use of electrical instruments, the power being delivered to the motor at any moment may be accurately measured, the power lost in the motor, rarely exceeding 15 per cent of the input, may also be measured; the machine consumes the remainder. The accuracy of the measurements is improved rather than otherwise if the motor is considerably larger than is actually required to drive the machine, so one motor may be used for testing a large variety of machines. When a number of machines are connected to a single line shaft the shaft may be motor-driven and the power required for the group measured in the same manner. When the machinery is arranged in this manner the power consumed by an individual machine may be obtained by noting the difference in the total when the machine is disconnected. The power consumed by the majority of machines is subject to wide variations, caused either by the nature of the machine itself or of the work it is doing. These fluctuations may occur with great frequency and rapidity, for which reason it may be desirable to measure the average horse-power or total work done dur-

ing an hour, day, week or month. Electrical instruments will accomplish this also—in fact, this is what is done by the ordinary meter, from whose readings the electric light and power companies determine the amount of their bill. We can even go a step further and use a meter that will record on paper the amount of power being used throughout the day.

The modern factor often is electrically driven, and instruments such as described above form a part of the engine room equipment and show the total amount of power being consumed at any and all times.

The same instruments that are used to measure the power taken by a motor will, of course, serve to measure the power used by electric lights. We know, from measurements already made, that 13 ordinary incandescent lights require while in use a little less than one horsepower; one ordinary arc lamp requires about the same amount of power. The power required for the various sizes and forms of electric lights being used at present is also a matter of record, so that the power required for lighting is determined as soon as we can decide upon the kind of lamp to be used and the number that will be in use at one time. The engine will have to deliver from 10 to 20 per cent. more power than is used by the lights in order to overcome the losses in the dynamo and wires.

Purely mechanical measurements of transmitted power are generally more difficult to make and less accurate than the electrical methods; they depend upon measurements of pull or weight and velocity, which are usually difficult to obtain under working conditions. When a belt is transmitting power there must be a difference in tension between the part approaching the working pulley and the part leaving it; this difference is the effective pull which causes the pulley to rotate; if it can be measured in pounds, the pull multiplied by the speed of the belt in feet per minute and divided by 33,000 will give the horsepower. The effective speed of the belt is readily obtained from the diameter and number of revolutions of the pulley; any slipping of the belt represents lost power, which should not be measured as going to the machine. A pair of "idle pulleys" serving merely to guide the belt may be mounted on a pivoted framework, the tight side of the belt passing around one and the loose side around the other: the difference in tension tends to rotate the frame, which may be retained in its proper position by a scale; from the reading of the scale we may calculate the difference in tension between the tight and loose sides of the belt. The apparatus will be cumbersome and an accurate reading difficult to obtain on account of fluctuations of power.

Instead of being rigidly connected to the shaft a pulley may drive the latter by means of a spring connection; the compression or extension of the spring will measure the force exerted, which may be reduced by experiment or calculation to the equivalent pull of a belt on a pulley of given size; the horse-power may then be calculated as before. The difficulty is to record the deflection of the spring, which, of course, turns with the shaft; this may be done by a system of levers and a loose collar sliding on the shaft. An arrangement may also be made by which the spring causes a pencil to move across a piece of paper; the paper may be caused to move at a uniform velocity by means of clockwork and a continuous record for the day obtained. The tendency of the spring to vibrate and the friction of the levers and recording mechanism is likely to make the results obtained somewhat inaccurate.

The power being developed by a steam engine may be measured by the "indicator"; an exceedingly interesting instrument, which is attached to the cylinder of the engine and records the steam pressure within the

cylinder and consequently upon the piston during all parts of the stroke of the latter. A slip of paper about six inches long is caused to move backward and forward beneath a pencil point with a speed that is always proportional to that of the piston; this is accomplished by attaching the paper to the surface of a small cylinder or "drum," which is caused to rotate by a string properly connected to some moving part of the engine. The steam pressure in the cylinder causes the pencil to move across the paper in a direction at right angles to the motion of the latter, the distance of the pencil point from the position it assumes when there is no steam turned on being proportional to the steam pressure. In this manner a chart or "diagram" is obtained which shows the pressure per square inch upon the piston during each part of its strokes. The pressure within the cylinder is controlled by the governor of the engine, consequently every variation in the load will produce a change in the diagram. The "Mean Effective Pressure" (MEP) or the average of the difference of pressure on the piston between its forward and return stroke during all parts of its travel may be obtained from the diagram; the area of the piston in square inches may be obtained by measuring the diameter of the cylinder. Multiplying this by the M.E.P. we have the average total pressure delivered to one side of the piston during a revolution of the engine. By connecting the indicator to the opposite end of the cylinder, which is generally effected by merely turning a "three-way cock," the pressure on the opposite side of the piston may be ascertained. The length of the stroke, which is readily measured, and the number of revolutions of the engine determine the feet traveled by the piston per minute; with this data the horse-power is readily obtained from the original definition and formula. The result obtained in the foregoing manner is termed the indicated horse-power (I. H. P.), and represents the amount actually delivered to the engine by the steam; 10 or 15 per cent. of this will probably be lost in overcoming the friction in the engine itself. This loss can be determined with a fair degree of accuracy by finding the I.H.P. when the engine has no external load. Subtracting this amount, which does not vary greatly with the load on the engine, from any card taken while running under load, gives the actual horse-power delivered at the time the card was taken; this is generally termed the brake horse-power (B.H.P.), and should be the amount measured by the brake previously described if the engine had been loaded in that manner instead of with shafting and machinery. The power required for a group of machines or for a single machine may be determined with more or less accuracy by noting the difference in the I.H.P. produced by throwing the load in question on and off. In order to obtain satisfactory results it is essential that the difference in I.H.P. should be a fair proportion of the total and that the load carried, in addition to the machinery being tested, should be fairly steady. If the test is repeated several times with practically uniform results one may feel quite confident of the accuracy; where readings of the I.H.P. remain uniform when the machine under test is thrown off, but variable when the machine is in operation we may assume, unless we have evidence to the contrary, that the power required to drive the machine varies and that the different results obtained are correct values for the moment at which the corresponding indicator diagrams were taken. When the power varies both when the machine is off and when it is in use no very trustworthy results can be obtained, although the average of a considerable number of diagrams should give an approximate measurement of the average power required.

The indicator not only shows the horse-power of the engine; it also tells

the engineer if the engine is running properly and using steam in an efficient manner. Most large plants have their engines indicated at regular intervals to insure economy of power, steam and coal. In less progressive engine rooms the waste that is disclosed by the indicator, if it is finally applied, is frequently very startling.

MINING ACCIDENTS

PRESENT CONDITIONS IN GREAT BRITAIN.

By T. Good

FROM 1842, when the first important mines regulation act was passed in Great Britain, down to the end of the nineteenth century, there was a remarkably steady decline in the mining accident death rate. Partly through the invention and adoption of improved appliances, partly through State control, and partly through the improvement in the general conditions and knowledge of the working miners, the accident death rate was reduced by more than 60 per cent. in sixty years. In the last half of the last century the annual number of mine workers killed was reduced from one in about every 250 employed to one in about every 770. So far so good. In the last few years, however, the movement has been in the opposite direction. Accidents are now on the increase. The progress has stopped and retrogression has set in. This is a matter of profound consequence. A series of big disasters have stirred the national conscience. A royal commission has been taking evidence upon the matter; mine owners, engineers and men of science have been conducting elaborate experiments with a view to lessening the dangers; the miners' unions have been pressing for more stringent State control, and the government has promised a "comprehensive bill to cover the whole ground" as soon as present inquiries and experiments are concluded. In these circumstances we may be permitted to offer a brief review of some of the problems involved in the general question of safe working. We give herewith a set of figures showing the great decline in the accident death rate down to the last ten years or so, and the subsequent increase:—

Annual Averages.

	Number Employed.	Deaths From Accidents.	Equal to
1846–1855	229,468	985	1 in every 249 employed
1856–1865	280,844	992	1 in every 286 employed
1866–1875	407,472	1,129	1 in every 366 employed
1876–1885	500,140	1,107	1 in every 461 employed
1886–1895	624,977	1,041	1 in every 601 employed
1896–1905	777,999	1,009	1 in every 769 employed
1906–1909	956,193	1,285	1 in every 745 employed

Taking the last ten years separately, we have these figures:

	Employed.	Deaths.	Equal to
1900	780,052	1,012	1 in every 770 employed
1901	806,735	1,101	1 in every 732 employed
1902	824,791	1,024	1 in every 805 employed
1903	842,006	1,072	1 in every 785 employed
1904	847,553	1,055	1 in every 803 employed
1905	858,373	1,159	1 in every 740 employed
1906	882,345	1,142	1 in every 772 employed
1907	940,618	1,245	1 in every 755 employed
1908	987,813	1,308	1 in every 755 employed
1909	1,013,998	1,447	1 in every 700 employed

Dividing the years into two five-year periods, we get this result:—

Averages

	Employed.	Deaths.	Equal to
1900–1904	818,239	1,052	1 in every 779 employed
1905–1909	936,629	1,220	1 in every 774 employed

How comes it that, despite the continual spread of scientific and technical knowledge, the increasing sobriety of the workers and more strict State supervision, accidents are now on the increase? We believe there are several reasons, and we may venture to discuss some of them.

The belief is strongly held by some miners that the recent increase of fires and explosions is the outcome of the wider application of electricity to coal mining. Since the existing rules on electricity came into force in 1903, there have been fewer than 60 deaths officially attributed to accidents connected with electrical installations. To be exact, 51 such deaths were recorded in the

seven years 1903-9. This is a small number, but the opinion is held by not a few that some recent explosions and fires, involving great loss of life, such as the Stanley pit disaster in Durham, have been caused by "the wires." Is it so? It is known that one of the chief agencies in colliery explosions is coal dust, and it has been demonstrated that coal dust can be ignited under critical conditions by almost any electrical appliance employed in a coal mine. It is at least possible for a blown fuse, broken wire or "short circuit" to spread disaster through igniting coal dust. As a means of minimizing this danger Mr. Garforth, of Altofts, and some other authorities who have experimented with coal dust, advise the spreading of stone dust.

Electricians declare that electricity has not yet had a fair trial in British coal mines save in rare cases, and they insist that, given suitable installations and efficient staffs of electrical engineers and wiremen, electricity could not be classed as dangerous. At present it is not denied—at any rate, it is not denied with any convincing emphasis—that electricity may spread disaster. What leading colliery electricians do emphatically insist upon—and this is the point of real importance—is that a number of mine owners refuse to employ either efficient or sufficient staffs to maintain their electrical installations at a reasonable pitch of safety.

Mr. Douglas S. Martin, in an article in the *Iron and Coal Trades Review,* March 4, 1910, insisted, as the minimum consistent with safety, that a colliery with a generating plant of anything over 300 kilowatts should be staffed by a competent electrical engineer in charge, an assistant engineer, and at least four wiremen. But Mr. Martin declares that some collieries with installations of several hundred kilowatts of power and many miles of cable employ no more than two wiremen under charge of an engineer who is not an electrician. Similar plants in manufacturing establishments would be staffed by from six to ten qualified men. And yet not nearly so many repairs are needed above ground as below ground. Falls and bulges of roof and sides cause innumerable injuries to wires, distributing boxes and other apparatus in a pit. Not only this, but the insulation on the wires is frequently damaged by the lads hanging their tub clips on the cables and by similar thoughtless tricks. There is an element of danger in electricity when properly controlled, but when the electrical staffs are neither efficient nor sufficient, and when the apparatus is roughly treated by the boys, and even by men, disasters are being invited.

Another possible cause of mischief, we venture to suggest, is the growing craze for amusement among the rising generation of miners. The bulk of our miners are no longer content to spend their evenings in the villages. Cheap tram cars take them to the city; the place of public amusement attracts; it is late when they return home and get to bed; they rise in the morning half dazed through insufficient sleep, and they enter the pit lacking that mental alertness which the natural dangers of their calling demand. True it is that miners, like other workers, are more sober than they used to be, so far as indulgence in strong drink is concerned; but can anyone deny that there is a marked growth of carelessness among all classes, and that the nerves of large numbers of our people are affected by the influences of an excess of ball games, cheap trips and evening entertainments, with their accompanying loss of rest? Strong nerves and keen vigilance are essential to safety in a coal mine, but these characteristics cannot be superabundant in persons who do not get sufficient sleep and quiet leisure.

Coincident with the craze for nerve-racking amusement we seem to

have a growth of indiscipline and lawlessness among our young men and boys. Strikes at short notice and upon trifling pretexts are becoming far too common. These certainly tend to create ill temper and militate against that smooth working necessary to the maximum of safety.

Then there is the question of State supervision. Have we too much or have we too little State control? We have a constant stream of mines regulation acts, amendment acts, and special rules. The intention behind these measures is good, but is there not ground for suspicion that the effects are sometimes bad? Mine managers are hedged about by too many laws and regulations. They are frequently trying to master their duties, as laid down in voluminous acts of Parliament, when they might be better employed studying the natural peculiarities of their own particular mines. The gentlemen who frame these laws seem to imagine that all mines can be worked upon one uniform principle. Sufficient allowance is not made for the varying natural conditions. Too many laws of an inflexible nature, imposed upon all mines and all managers regardless of local and individual circumstances, must have the effect of checking initiative and inspiring the idea that it is more the business of the State than the manager to safeguard the workers. The State, having gone so far in the matter of law-making, surely ought to follow this up by maintaining an inspector at every mine to see that the law is observed alike by worker and employer. If the State is so eager to protect labor that it leaves mine-owners and managers with but a mere shadow of freedom, then let the State carry its policy to a logical issue and relieve owners and managers of the duty of looking after the workers' as well as their own interests. Let there be an ample staff of inspectors to attend to the safety of the workers and leave the managers free to attend the business of their employers, subject to the requirements of the inspectors. Either let us have less State interference or full State control in matters of safety. The policy of the State being what it now is, it is not sufficient that the inspectors employed by the State should only, as a general rule, visit the mines in case of accident. Let the inspectors be on the spot constantly to prevent accidents. If we had fewer laws and more inspectors it would be better. In the workmen's compensation law, for example, we have evidence that the State, through excessive zeal and misdirected effort, may do more harm than good to the very workers it seeks to benefit. It is not unlikely that this law is one of the potent causes of the recent increase of mining accidents. That it has been the means of increasing workshop accidents is beyond dispute. This law puts a premium upon young workmen. In many manufacturing trades employers began to weed out their elderly men after the compensation bill was passed. In doing this the employers were, as a matter of fact, weeding out the safest men. As a general rule it is the young man, and not the older one, who is most likely to cause an accident, and most likely to produce injury to others through leaving things unsafe. The older man has most experience and can exercise the greatest caution. Employers were not justified, on the score of accidents alone, in turning adrift the elder workers, but smarting under what they considered an unfair law—a law not permitting the aged and delicate to contract out—many employers did give preference to young and strong workers. And this, beyond all dispute, was one of the main reasons why, within ten years of the passing of the first workmen's compensation act, the number of workpeople injured in factories and workshops increased by 115 per cent., and the number actually killed by 62 per cent. Here is the proved case of an act spe-

cially designed to benefit the workers resulting in an aggravation of unemployment and a multiplication of accidents.

This policy of discarding the aged worker in consequence of the law of compensation has not been so generally adopted in coal mining as in some manufacturing trades, but that it has been adopted in some mines, that it has involved the loss of experienced men and caused a diminution of safety, is highly probable.

We submit, therefore, that the elimination of aged workers on account of the compensation law, the growing spirit of indiscipline and carelessness among the young miners, the craze for nerve-destroying amusement, too much State interference in small matters without adequate inspection, and lack of care in the application of electricity to coal mining are some of the factors in the recent deplorable rise in the accident death rate.

But, bad though we believe these things to be, we hold that in the new mines eight hours act an agency has been introduced which will add still further to the dangers of mining. That the eight hours act has already provoked strikes and threats of strikes, that it has embittered feeling between miners and mine owners, and even between the miners and their own leaders, and that it has resulted in loss of trade and wages, are by no means the worst features of this measure. The real mischief will come when mine managers and miners have settled down to make the best of this new law—that is, assuming the law is not altered. What the compensation law has done in the workshop the eight hours law will do in the mine—banish the aged, experienced, cautious and steady worker. Parliament and the nation will not realize the real meaning of a law like this, applied to all mines regardless of the widely varying natural conditions, until both men and masters set to work in earnest to "speed up," and the results are set out in our accident tables. Then the blundering, not to say criminal, character of unjustifiable legislative interference will be revealed in all its ugly deformity. A coal mine is the last place in the world from which the aged worker should be banished. It is the last place in the world where undue "speeding up" should be encouraged. The eight hours act will impel managers to get rid of their aged men, and it will encourage them to make "speeding up" a fine art. It is of little use the State passing innumerable acts compelling the adoption of safety devices and rescue appliances if at the same time it enacts other measures which provoke and increase the dangers of the industry.

This new law will bring into existence at least three agencies that will add to the risks of mining. First there will be mechanical speeding up, the acceleration of haulage and windage, where this is possible; secondly, there will be the efforts of some of the miners themselves to counterbalance, as far as possible, the reduction in their earning time by less attention to propping, faults of roof, etc., and thirdly, there will be the loss of the elderly pitmen. Managers of many mines will have little option but to employ only the most vigorous men, the men who can get the most coal in the least time. Not only will there be a gradual substitution of inexperience and reckless men for experienced and cautious men, and all the increase of danger that involves, in the first instance; but it must be remembered that the aged pitman frequently exercises a vigilance over and gives valuable advice to his younger mates. The loss of the elderly pitman—the loss of his caution, watchfulness and advice—will be an incalculable loss. As direct results of this eight hours act the aged and delicate will be turned adrift, the young and strong will be goaded on, and accidents will increase. Unemployment will be ag-

gravated, toil intensified, and dangers multiplied. The mines eight hours act, unless it is speedily amended, will prove costily in life, limb and suffering as well as in pounds, shillings and pence. Indeed, the accidents already recorded during the few months it has been in operation are higher than the average for a good many years.

We are told that with increased care on the part of the working miners themselves, particularly in watching for bulges and possible falls of roof, with more strict discipline among the youths, with more efficient inspection and fewer harassing "rules," with a sufficient number of competent men to look after every underground electarical installation; with the spreading of stone dust wherever coal dust accumulates; with the provision of safety chambers for men to get into in case of fire or explosion, and ample signalling arrangements between these chambers and the pit head; with rescue stations in every mining district and breathing apparatus at every mine, and last, but not least, the repeal or drastic amendment of the eight hours act, we should once more see a steady decline instead of an increase in our mining accident death rate.

THE PROPULSION OF CARGO BOATS

By R. M. Neilson

II. PROPULSION BY INTERNAL-COMBUSTION ENGINES.

In the first portion of this discussion, published in the July issue, the author examined the relative advantages of reciprocating engines and steam turbines, and also referred to the proposed use of speed reduction gearing to enable high-speed turbines to be employed for the operation of screw propellers at moderate rotative speeds. The advantages of superheating were shown and the various systems illustrated by practical examples. The present article closes the discussion with a consideration of the applicability of the internal-combustion engine to the practical propulsion of cargo boats.—The Editor.

THE last system of propulsion for cargo boats, which will be considered in this article, is that by internal combustion engines.

Internal combustion engines have not as yet been employed as the propelling machinery of cargo boats except for vessels of comparatively small size and power, but the success that has been met with in recent years in the propulsion of small vessels, and the improvements that have recently been effected in internal combustion engines, together with the more widely spread knowledge of these engines and the decrease in prejudice against them—all these considerations taken together render it necessary to seriously consider the internal combustion engine as a possible prime mover for use, even at the present day, for propelling cargo vessels. The success which has been attained within the last few years with "motor" boats driven by explosion engines employing a light spirit, has little relevancy to the problem now being considered. Coal and heavy oil are the only fuels that need be considered in this article; and strong, durable engines, with moderate propeller speeds, are desirable for cargo boats.

Until recently the suggestion to employ an internal combustion engine to drive a cargo boat over 200 horsepower did not constitute a practical proposition which a ship owner would seriously consider; at the present day the case is different. The advances made in connection with internal combustion engines during the last few years may not seem great (engines for motor cars, or boats, or for aeronautical purposes excepted), but they have been sufficient to place the internal combustion engine at the present day in the position of a competitor for the propulsion of the smaller classes of cargo boat, and a competitor which cannot be ignored.

The advantages of internal combustion engines for ship propulsion have, without doubt, been often overrated, and unfair comparisons have been made; and the writer is not of opinion that internal combustion engines have yet been proved to be suitable for driving battleships, cruisers or Atlantic liners; but an impartial investigation of the subject must force the admission that there is at present no serious objection to their employment for cargo boats of powers up to about 1,000 horsepower, and that for such vessels the only questions to be considered in connection with propelling machinery are of a financial nature. It may be said that the limit to power above mentioned cuts off the more numerous and more important class of cargo boats—vessels of more than 1,000 horsepower; the writer admits this. The limit to power may, however, be expected to rise, whether at an early date or only after many years, cannot safely be predicted at present.

Internal combustion propulsive machinery for cargo boats may be divided into two classes, the first

class involving the use of gas producers and gas engines, and the second class the use of heavy oil engines.

GAS PRODUCERS AND GAS ENGINES

All gas engines which at the present day could be recommended for ship propulsion are of the explosion type. Both the four-stroke (Otto) and the two-stroke (Clerk) cycle are in extensive use on land, and either could be used for ship propulsion. The two-stroke cycle allows of the building of a lighter engine for the same power, which is an advantage on board ship; but a much greater advantage possessed by this cycle rests in the fact that for a given maximum allowable irregularity in turning moment and a given maximum dimension of cylinder, the number of cylinders required in a two-stroke cycle engine will be only half that required on a four-stroke cycle engine for the same power; and therefore an engine working on the former cycle will be little more than half the length of an engine on the latter.

As regards the producer, this may be either of the pressure or the suction type, the relative advantages of the two systems, the design of the producer, and the cleansing of the gas, constitute important details which, however, would require more space to deal with adequately than is here available.

The gas engine installation on H. M. S. *Rattler* has already been decribed in CASSIER'S MAGAZINE.* Suffice it to say here that the *Rattler* is a gunboat of an old type (she was built in 1886), and has the following dimensions: Length, 165 feet; beam, 29 feet; mean draught, 11 feet 2 inches; displacement about 715 tons. The vessel was originally fitted with reciprocating steam engines, which under forced draught are said to have indicated 1,000 horse-power and propelled the ship at 13 knots, while under natural draught the indicated horse-power was 600 and the speed 11.5 knots. The steam engines and boilers were removed and replaced by a Beardmore-Capitaine gas engine and suction producer of about 500 brake horsepower. With both types of machinery a single screw was employed.

The gas engines comprise five vertical single-acting cylinders, with a flywheel arranged in an intermediate position on the crank shaft. Each cylinder is 20 inches in diameter, and the stroke is 24 inches; and the engine is intended to run at about 120 revolutions per minute.

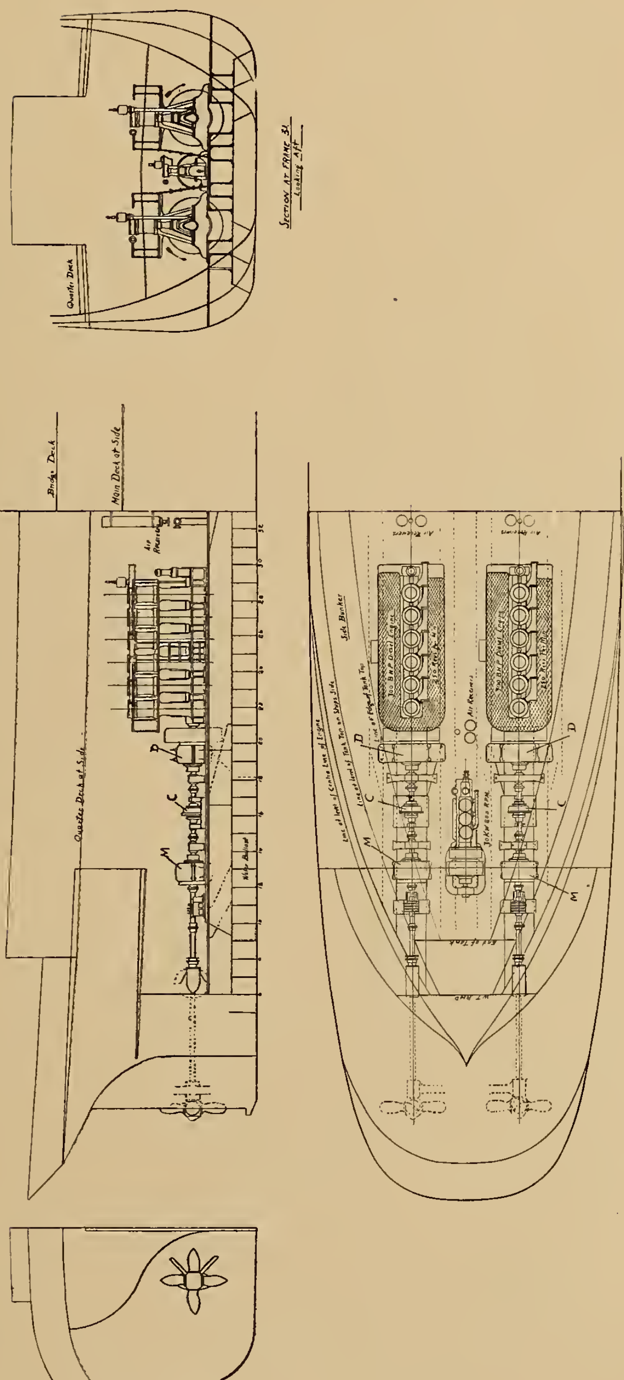
HEAVY OIL ENGINES

The two types of heavy oil engine which would appear to be most suitable for use on cargo boats are (1) the Diesel type, in which oil is injected into the combustion chamber at the end of the compression stroke and ignited as it enters, due to the temperature of compression, and (2) the Hornsby type, in which the oil is sprayed on to a hot surface within the combustion chamber and ignited by contact with this surface. Both these types of engine are run both on the two-stroke and the four-stroke cycle.

The Diesel engine has been brought to great perfection and reliability in Great Britain by the Mirrlees Watson Company, Ltd., of Glasgow, and by their successors in oil engine work, Messrs. Mirrlees, Bickerton & Day, Ltd., of Hazel Grove, near Stockport. The engine, as made by these firms, is of the four-stroke single-acting type, and is started and reversed by means of compressed air supplied from reservoirs which are charged by a two-stage compressor driven directly by the engine.

The illustrations show a proposed arrangement of Mirrlees-Diesel engines for propelling an oil-carrying vessel of 1,800 tons displacement. The length of the ship is 194 feet, beam 35 feet, and draught 12 feet. There are two sets of six-cylinder engines, each set being capable of developing 300 brake-horse-power

* November, 1908, Vol. XXXV, page 193.



ARRANGEMENT OF DIESEL OIL ENGINES FOR MARINE SERVICE. THE MIRRLEES-WATSON COMPANY, LTD., GLASGOW

when running at 250 revolutions per minute. The engines are intended to drive the boat at a speed of 9½ knots.

When proceeding ahead at any speed between full speed and half speed, the engine and propeller shafts are coupled together by means of a combined friction and positive clutch C, the speed being varied between these limits by controlling apparatus fitted on the engine. On each engine shaft is secured a dynamo, D, capable of developing about 60 brake-horse-power at 125 revolutions per minute, and on each propeller shaft is secured a reversible variable speed motor M, capable of absorbing the full power of the dynamo; the usual bearings, thrust block, etc., are provided.

When manœuvring ahead and astern with the propellers, or proceeding ahead at less than half speed, the engine and propeller shafts are disconnected and the dynamos on the engine shafts operate the motors on the propeller shafts, the engine and dynamos running at a constant speed of 125 revolutions per minute, and the speed and direction of rotation for the motors being conrolled electrically by varying the intensity and direction of the current in the field windings. In emergency, such as to avoid collision when running electrically, it is possible to increase the speed of the engine up to 250 revolutions per minute, whereby the dynamos and motors are overloaded for a short period, which overload they will stand safely for a reasonable time. The electrical arrangements are so disposed that either dynamo can operate either or both motors, thus providing against a breakdown of either dynamo or engine. The starting compressed air receivers for the engines are independent, but are cross-connected so that either may act as a reserve to the other.

An auxiliary Diesel engine of 45 brake-horse-power coupled to a 30-kilowatt generator provides the necessary power for lighting the vessel and for working electrical auxilaries. This engine has a set of starting receivers of its own, and these are interconnected with those of the main engines, thus providing an additional safeguard against loss of starting air.

The total weight of the propelling machinery, including oil engines, air compressors, air reservoirs, dynamos, motors, shafting, clutches, thrust blocks and propellers is only 110 tons; but it must be remembered that at full speed the propellers make 250 revolutions per minute.

Although the arrangement shown in the illustrations has only been proposed and has not yet been fitted in a vessel, the engines are of the standard design of Messrs. Mirrlees, Bickerton & Day, Ltd.; and several engines of the size of the main engines shown in the figures have been constructed by the firm and are now running and giving satisfaction.

An engine of the Hornsby type which is at present employed to a considerable extent in the driving of fishing boats and other small craft is that built by the J. & C. G. Bolinders Co., Ltd., of Stockholm, Sweden. This engine works on a two-stroke cycle, and no valves are employed except that through which air is drawn into the crank chamber on the up-stroke of the piston for admission into the engine cylinder at the end of the downstroke. Oil is at the end of the compression stroke sprayed into an igniter bulb situated at the top of the combustion chamber, which bulb is kept sufficiently hot by the explosions during the normal working of the engines. For starting the engine the bulb is heated by means of an external lamp. Reversal is effected by cutting out the main fuel feed pumps (one for each cylinder), and putting into action an auxiliary fuel pump which injects fuel oil into the cylinder (or one of the cylinders) at an early period of the compression stroke. The premature explosions thus produced cause reversal of the

engine in a few revolutions—say in about a second in an 80 horsepower engine—and the auxiliary pump is then cut out and the main pumps returned to action. A single to and fro movement of a lever affects the reversal of the engine.

The writer had an opportunity a short time ago, through the courtesy of Messrs. Douglas, Primrose & Co., the Glasgow agents of the Bolinders Company, to witness the working of a Bolinders 80-horse-power engine on a large Swedish fishing boat. The engine made 300 to 400 revolutions per minute, and was easily started and reversed.

Mirrlees-Diesel engines have been built of a size to give 125 brake-horse-power per cylinder, and Bolinders engines of a size to give 80 brake-horse-power per cylinder. There should be no difficulty in constructing such engines with four, five or six cylinders to give about 480 or 500 brake-horse-power, so that two sets of such engines, each driving a propeller shaft, should give an aggregate propulsive effort equal to a single steam engine of about 1,000 indicated horse-power, allowing for a less propeller efficiency with the oil engines.

A strong objection which used to exist to the employment of internal combustion engines for ship propulsion lay in the difficulty or unreliability of the starting or reversing operations. These difficulties have been completely removed in the two types of engines above mentioned. In the Bolinders engine the devices for starting and reversing have already been described. The Mirrlees-Diesel engine starts by means of compressed air with the utmost reliability; and reversing in engines suitable for cargo boats is effected by an electric gear of the nature of that described with reference to the accompanying illustrations.

If it is admitted that propulsion of cargo boats by gas or oil engines up to 1,000 horsepower per vessel constitutes a practical proposition (as the writer has sought to show in this case) this system of propulsion must then have its advantages and disadvantages compared with those of other systems. So little has been done in the way of marine propulsion by gas or heavy oil engines that the weights of engines which it would be desirable to employ in cargo boats cannot be given with exactitude. The weights of gas engines and producers, or of oil engines, should, however, be less than the weights of steam reciprocating propelling machinery, taking suitable propeller speeds in all cases. The reduction in weight of total propelling machinery, as far as can be estimated at present, would probably be between 10 and 40 per cent. Comparisons of weight for naval purposes are, of course, of little value in the present investigation.

The weight of and the space occupied by propelling machinery being less for gas or oil motors than for steam engines, it follows that a vessel of less displacement will suffice to carry the same cargo. Moreover, owing to the greater efficiency obtained by adopting the internal combustion principle, a less weight of fuel will suffice for a voyage of given duration. Both these statements apply in all cases, but in vessels making short voyages, and in which the weight of fuel carried is small, the second consideration is of little moment. For long voyages, however, without re-fueling the bunker or tank capacity can be very much reduced for gas or oil motors, and greater economy in displacement can therefore be effected in long voyage than in short voyage vessels. Short voyages will be more usual for the size of cargo boats considered. If for a vessel of, say, 4,000 tons displacement and 1,000 indicated horse-power, 100 tons weight could be saved in machinery and fuel by adopting gas engines and producers with coal fuel, or oil engines using heavy oil fuel in place of reciprocating steam engines with boilers burn-

ing coal or oil, the displacement of the vessel could be reduced probably by a little more than 100 tons; and a reduction in the initial cost of the vessel, excluding machinery, of between £300 and £500 might be effected. The exact reduction would vary considerably according to the conditions of the case. If the cost of machinery were unchanged, then the saving in initial cost of the complete vessel would be approximately as above mentioned; and in any case the difference in initial cost would be too small to be a serious factor in determining the system of propulsion.

A distinct advantage of the internal combustion engine has reference to the saving in stoking. Gas producers do not require to be fed with coal at such frequent intervals as do steam boilers, and the work of stoking is not so arduous. With oil engines the fuel is pumped directly from the tanks into the engine so that a single man can attend to the whole machinery.

It will not be fair, however, to compare oil engines with steam plants using coal as fuel. Plants involving the use of gas engines and producers can be compared with plants involving steam engines and boilers burning coal; but the steam plant to be compared with oil engines must involve the employment of oil as fuel in the boilers.

Cost of Fuel.

As regards cost of fuel, the consumption of coal with internal combustion engines may be taken as about three-quarters of a pound per indicated horse-power per hour, while twice that rate of consumption represents good practice in cargo boats with reciprocating steam engines employing saturated steam and boilers burning good coal. For a vessel of 1,000 indicated horse-power this represents a saving of about 8 tons a day. With 250 days running in the year, the annual saving would be £2,000, with coal at £1 a ton, and £1,500 with coal at 15 shillings. For an average of 70 hours' running in the week, the saving would be £1,220 a year for coal at 20 shillings, and £915 for coal at 15 shillings.

As regards oil fuel, this, if burned in a boiler and the steam supplied in a saturated and, to a certain extent, wet state to a triple-expansion or quadruple-expansion engine, will produce about one indicated horse-power for 1 to 1.4 pounds of oil per hour. An oil engine, on the other hand, will use only from 0.45 to 0.7 pounds of oil per hour per brake-horse-power. Allowing for a difference of 0.6 pounds of oil per indicated horse-power per hour between external and internal combustion, then for a vessel of 1,000 indicated horse-power the saving effected by adopting internal combustion engines would be about 6½ tons per day. The price of oil varies greatly, depending on the nature of the oil, on the port at which it is purchased, and on the market conditions.

The table herewith gives the annual saving to be effected according to the price of oil and the aggregate duration of time that the vessel is under way in the year. For example, if oil costs fifty shillings a ton, and the vessel runs 200 complete days in the year, the yearly saving will be £3,220.

ANNUAL SAVING WITH OIL ENGINES.

Cost of Oil Fuel. per Ton.	Full Days' Running per Annum. 250	200	150
£ s. d.	£	£	£
3 10 0	5,630	4,500	3,380
3 0 0	4,820	3,860	2,900
2 10 0	4,020	3,220	2,410
2 0 0	3,220	2,580	1,930
1 10 0	2,410	1,930	1,450

In the above comparisons of weight and cost, it has been assumed that the internal combustion engines would run at about 100 revolutions per minute, so that the propeller efficiency (with twin screws) would not be far different from that obtained with a reciprocating steam engine driving a single screw at 60 to 90 revolutions per minute. If any com-

parisons are made between high-speed oil engines and low-speed steam engines, allowance must of course be made for the difference in propeller efficiency.

Conclusions.

If mechanical gearing under the rough-and-tumble conditions of cargo boat service proves as satisfactory as it has given promise of on trial, and if the frictional losses in the gearing, including the losses in the wheel and pinion bearings, amount to not more than about 6 per cent. of the power transmitted—which is a much greater loss than has been experienced with either the Parsons or the Melville-Macalpine gears on trial—the writer is convinced that the best steam propulsion machinery for cargo boats is undoubtedly that which comprises high-speed steam turbines and mechanical reduction gearing. A propulsion scheme of this nature would have an advantage over the usual reciprocating steam engine direct drive both as regards initial cost of vessel with machinery and as regards working costs; and this statement applies whether saturated or superheated steam is employed, it being assumed that if superheated steam is used on the one case it will also be used in the other.

As regards the other steam plant schemes which have been discussed in these articles, those involving high-speed steam turbines with low-speed propellers and electric or hydraulic transmission of power would not be so efficient as the propulsion scheme with a high-speed turbine or turbines and mechanical gearing; and the electrical scheme would, moreover, involve a heavier initial outlay. It may further be remarked that the spending of money on research work on electric or hydraulic transmission of power cannot be recommended until the mechanical gearing scheme is tested in active service.

The jet propulsion scheme referred to in the first portion of these articles would have certain advantages over that with mechanical gearing; but at the present moment it cannot be recommended in the absence of sufficient knowledge as to probable efficiency; and it might turn out to be hopelessly out of the running.

As regards the recipro-turbine combination with direct propeller drive, this scheme allows of the attainment of an efficiency about equal to that which could be obtained with a high-speed turbine and mechanical gearing, allowing for a slightly inferior propeller efficiency with the shaft or shafts directly turbine-driven. The recipro-turbine combination involves, however, machinery which is, relatively speaking, heavy, bulky and complicated; and no ship owner would be well advised to choose it for a cargo boat if mechanical gearing proves in service to be efficient, reliable and without serious objection.

If, therefore, mechanical gearing proves satisfactory, the ship owner need have no hesitation as to his choice of steam plant, if steam plant is to be employed, but he will still have two questions to answer: (1) Shall he adopt steam plant or shall he employ internal combustion engines? (2) Shall he employ coal or heavy oil as fuel?

The fuel question is chiefly one of cost of supplies. It has been said that oil for fuel is not always obtainable at ports at which it might be required. The output of heavy oil suitable as fuel is not, however, limited to any one portion of the world, and if there were sufficient demand for oil, owing to the price being sufficiently low—and this necessarily assumes that the production is sufficient to meet the demand—then oil could be obtained at seaports nearly as readily as coal. On questions connected with the world's oil supplies and the probable price of heavy oils in the near future experts differ, and such questions are boyend the scope of the present article.

Oil weighs less than coal for the same heat energy, and it can be

stowed into considerably less space than coal, weight for weight, so that the employment of oil calls for very much less bunker capacity than coal. Moreover, places can be utilized for stowing oil which would not be applicable for holding coal, so that a considerable saving in space may be effected by employing oil as fuel, which may allow of a reduction in the light weight of a vessel for a given cargo-carrying capacity. Moreover, a reduction in boiler capacity can be effected by employing oil owing to the periodic cleaning of fires necessary with coal; and the absence of trimming, which is necessary with coal, represents another advantage of oil fuel. All these points contribute to the reduction of the initial cost of the vessel; and the oil fuel has the advantages as regards wages in the running costs.

The cost of fuel is, however, relatively such an important question that unless oil can be sold at a price not greatly in excess of that of coal—the comparison being made on a thermal basis—oil has, in the writer's opinion, little chance of being extensively used for the propulsion of cargo boats, whether employed to generate steam or consumed in internal combustion engines.

As regards the other question as to whether internal combustion engines are to be employed, or high-speed steam turbines with mechanical gearing, this question is, to a certain extent, influenced by the fuel question because the use of oil fuel for internal combustion engines obviates the necessity of producers; but even with coal fuel the internal combustion engine will be a serious competitor. The writer is inclined to the belief that where coal is the fuel there will be little to choose between the internal combustion engine with gas producer, and the high-speed steam turbine with boilers and mechanical gearing, for powers up to 1,000 horse-power, and that where or when oil is employed as fuel the internal combustion engine will be preferable up to the power stated. For powers above 1,000 horse-power the writer is of opinion that the steam plant is to be preferred. It may be necessary, however, to make exceptions to these rules, and it would be well if the question were considered independently for every proposed new vessel. Moreover, conditions may alter in a few years, and it would not be surprising if further improvements in internal combustion engines made them at the end of a few years from now masters of the situation as regards all sizes of cargo boats working under all conditions.

When high-speed steam turbines with mechanical gearing are employed the writer believes that the steam will be superheated in the majority of cases, as the advantages of adopting superheat with high-speed turbines would appear to distinctly overweigh the disadvantages, except possibly as regards small vessels or vessels running only a comparatively small number of hours in the year, in which cases the yearly fuel bill will be relatively small.

We have been assuming that mechanical gearing, used in conjunction with high-speed steam turbines, proves a success. If it should not prove successful, the internal combustion engine will not experience such formidable competition, and the writer considers that in such a case internal combustion engines would certainly be preferable for all cargo vessels of 1,000 horsepower and under, whether employing coal or oil as fuel. For vessels of powers of 1,000 to 3,000 horsepower, the writer would generally recommend reciprocating steam engines; and for powers of over 3,000, and in certain cases between 2,000 and 3,000, the recipro-turbine combination would appear to represent the best system of propulsion.

The writer would be inclined to favour generally the employment of superheated steam for the steam-driven ships, whether or not a low pressure turbine is employed.

Current Topics

THE change which has taken place in the general consideration of the subject of the application of electric traction to main line railway appears very clearly in the important paper presented before the joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers in London by Mr. George Westinghouse, president of the latter society.

When electric traction was first proposed it was considered impracticable for several reasons, the principal one being the immense sacrifice involved in scrapping the steam locomotives already in active service and capable of many years of further useful work. When later it was found most desirable to employ electric locomotives for use in tunnels and underground connections where the presence of smoke and steam was objectionable, the use of electricity was conceded as a special matter, not bearing in any way upon the great portion of the department of motive power. Gradually, however, the use of electricity has become extended to a point where it is most important to make plans for future standardization, and this is the feature which is most forcibly emphasized in the paper by Mr. Westinghouse.

One of the immense advantages of railways in the transport of passengers and merchandise lies in the possibility of making continuous journeys over long distances without interruption. The development of this advantage has impressed upon the railway engineer the necessity of such a degree of interchangeability as will permit the rolling stock of one railway to be operated directly upon all others.

Mr. Westinghouse calls attention to the serious obstacle which the use of different gauges of track opposed to the interchange of traffic and shows the great advantages which have followed by the general use of the Stephenson gauge of 4 ft. 8½ in. Similar advantages have resulted from the adoption of interchangeable types of couplings, of interchangeable brake systems, as well as of heating apparatus, and of signals for trains. Most of these have had to make their way in the face of previous differences, and the cost in time and money incurred because of the absence of any previous standardization has been both great and unnecessary.

The railway engineer is now confronted with a similar state of affairs in connection with the use of electric power for traction. Already a number of main line railways are

using electricity upon certain portions of their systems for tunnels, for entrance into cities in which steam locomotives are objectionable, and for certain departments of suburban service. The extension of these electrified portions means that ultimately they will meet, and unless the various railways conduct this extension work upon plans which are capable of standardization, at least to such an extent that interchangeability is possible, the result will be much the same as in the days of different gauges of track.

It is certain that such standardization is a matter involving many difficulties, but the difficulties existing at the present time are slight compared with what may exist if the work is postponed much longer. Such standardization, if properly effected, does not necessarily mean a limitation to a single system of construction, but simply that the parts which must be operated together shall be designed with that end in view. The "paralyzing influence of standardization" occurs only when it is carried too far, and when the attempt to force some preconceived details is permitted to overbalance the real essentials demanded for commercial interchangeability.

Mr. Westinghouse has not spoken a moment too soon; already some work has doubtless been done which will have to be undone, but the points which must be standardized in order that future confusion, delay and unnecessary expense shall be minimized ought to be placed in the hands of a competent body of impartial engineers at the earliest possible moment.

In connection with the subject of the introduction of electric traction in the place of the steam locomotive, the objection based upon enormous loss due to the abandonment of present motive power equipment may be noticed. That such expense must be incurred cannot be denied; no great advance of such a nature was ever effected without the expenditure of sums far beyond those required for the system which was superseded. One has only to turn back to the discussions which took place when steam railways were introduced to find arguments concerning the immense cost of locomotives over stage coaches to find much that has since been repeated. It is not absolute costs which should be considered so much as relative expenditures, comparing results in both cases with the costs involved in their production.

Another point which has not always been taken into account appears in the fact that equipment is continually being replaced in any case, and that the time required for the installation of electrical equipment period during which the present machinery would have outlived its usefulness. No one proposes to scrap all the steam locomotives at once, and no existing manufacturing facilities could possibly replace such equipment with the new machinery in a brief time. Doubtless the introduction of electric traction will be a matter of growth, various sections and zones being extended, and their connections lengthened until the old is replaced by the new in about the time which would have been demanded even had the replacement been of the same kind. One has only to look at the manner in which transformations of similar nature have been effected in ocean transport to perceive how these things settle themselves as matters of growth without sudden changes or excessive wastefulness in current equipment.

COUNT FERDINAND ZEPPELIN

A BIOGRAPHICAL SKETCH

Ferdinand, Count von Zeppelin, whose perseverance and largely successful efforts in the production of an operative type of dirigible balloon in Germany, is a man of wide experience in military affairs, and a practical scientist whose career is of much interest to engineers

Born in 1838, near Friedrichshafen, on the Lake of Constance, he received his education at the Polytechnic School at Stuttgart, at the Military Academy at Ludwigsburg, and at the University of Tübingen.

Ludwigsburg itself contains an imposing monument by the sculptor Dannecker, erected to the memory of his ancestor, Count Zeppelin, minister to King Frederick, this memorial having been erected by the order of the latter in 1801.

His military career began in the German army in 1861, and two years later he was detailed for observation duty with the Union army in the Civil War in the United States, serving with distinction as a cavalry officer until the close of the war in 1865. His inclination toward aeronautics appeared even at this early period of his career, and while connected with the army of the Potomac he made an ascent in a captive balloon to make observations of the enemy.

He narrowly escaped capture at the battle of Fredericksburg, where he was serving on the staff of General Carl Schurz, and displayed marked bravery in action. On his return to Germany he took part in the Austro-Prussian war of 1866, and in the Franco-Prussian war of 1870, making a brilliant dash across the frontier into French territory only a few hours after the declaration of war, being accompanied by four officers and seven troopers, all of whom were either killed or captured, Zeppelin himself alone making his escape. He served throughout the war with France, and after the formation of the German Empire he became plenipotentiary of his native country of Würtemburg at Berlin, and representative in the Federal Council of the Empire.

It was in 1891 that Count Zeppelin began to make experiments with dirigible balloons, devoting to it his time, energy and personal fortune. The previous efforts of Col. Renard, in France, had been made with a cigar-shaped balloon, without stiffening framework, and deriving its motive power from a heavy primary electric battery.

During the intervening years, two important developments had occurred which modified the situation very materially; the electric decomposition of corundum had furnished cheap aluminum, and the demands of the automobile had produced the light-weight, high-power gasoline motor. Zeppelin adapted both of these to his ideas for the construction of a new type of dirigible balloon, employing the light metal for the construction of a stiffening framework, and using the motor of his fellow countryman, Daimler, at Stuttgart, for his engines.

The magnitude of this work, and the number of failures which accompanied these experiments, would have discouraged almost any man, but Zeppelin kept on in the face of expenditures which exhausted his entire private means, and led him to be considered by many as a man who had sacrificed fortune, reputation and the better part of his life in a vain endeavour.

In 1908, however, his great dirig-

ible, No. 4, made a successful trip from Friedrichshafen to Frankfort, and when this success was followed by a disaster which destroyed the machine, funds were raised by the government and by popular subscription to enable the work to be continued.

On June 22, of this year, the *Duetschland,* the latest Zeppelin dirigible, opened what was intended to be a regular aerial service, and carried twelve persons from the Lake of Constance to Düsseldorf, a distance of 250 miles; making an average speed of 28 miles an hour.

A later trip met with disaster, but the successes which have been attained with the later Zeppelin balloons indicate that so far as aerial navigation with large dirigibles is concerned, the system so laboriously developed by Count Zeppelin will have its practical uses, and especially in military service the Zeppelin balloon will prove an important factor.

The principal features of the Zeppelin type, as evolved from this long series of experimental work on the large scale, include the use of a light metallic framework, forming what is practically a cylindrical structure with pointed ends, this containing a number of isolated spherical balloons filled with gas to produce the sustaining power. The whole is covered by a protecting envelope, so that the external appearance indicates nothing of the interior arrangement. Two cars connected by a lighter passageway, are suspended from the balloon, and each car is provided with two propellers, one on each side, each propeller having its own engine. All the Zeppelins have been of large size, the *Deutschland* being 485 feet long and 46 feet in diameter, with a capacity of nearly 25,000 cubic yards, and a lifting power of 44,000 pounds. Notwithstanding all the discouragements which have been experienced by Count Zeppelin, he may feel that his work has not been in vain, and the extent to which he has demonstrated to government, to capitalists and to the public the feasibility of his plans is sufficient to assure his position as the leader in the "lighter-than-air" type of flying machine.

IRA H. WOOLSON,

Consulting Engineer to the National Board of Fire Underwriters.

See page 480.

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THE BRUSSELS INTERNATIONAL EXHIBITION

By J. O. Newman

WHEN the writer visited the grounds of the exhibition twelve months ago, a general survey of the enormous amount of work already executed indicated that the authorities responsible for the management would probably attain their avowed object of contributing a record in readiness. However, although the exhibition opened on April 23, and by the end of December last not only the buildings but all fittings were to be absolutely complete and ready for the reception of exhibits, something remains still to be done at the time of writing. The hard winter which intervened between the dates mentioned is partly to blame for this.

The exhibition is situated in the plain of Solbosch adjoining the Bois de la Cambre, and has the dark masses of the Forest of Soignies as a background in the east. The suburbs of Brussels on the west are entirely hidden by the exhibition buildings, and otherwise such good use has been made of the topographical features of the ground that the whole represents quite a separate and independent world, which includes the highest point above sea level which exists between Brussels and the sea.

An extension of the magnificent Avenue Louise and electric tramways, for which a separate terminus has been constructed inside the gates of the exhibition, provides ample means of access at a cheap rate. This terminus is in direct connection with all the main and vicinal railway stations, and thence a double track of tramways enables visitors to reach any part of the grounds without walking. Rikshas and bath chairs are also provided.

The exhibition is under the patronage of the King of Belgium, and the government is partaking officially, but the enterprise was promoted by a company with a capital of 2,600,000 francs, and, through the courtesy of Count de Burgh, the general manager, we were able to procure the service of M. Fourbin, the chief superintendent, who proved an able and valuable guide on our visit.

The buildings generally are made of a framework of wood and iron, or, in the case of the smaller pavilions, of wood only.

The walls are covered with "staff," a mixture of hemp threads and plaster of paris, which is particularly well adapted for modeled pieces, and, being light, can be cast in very large sections. In appearance, "staff" re-

BRUSSELS EXPOSITION, MAIN ENTRANCE

sembles Keane's cement in whiteness, but it can be coloured either before or after moulding.

The center of the main building presents an elegant front, designed on large lines, giving an impression of solidity and repose much in harmony with its wooded surroundings. This main building contains the administrative offices near the entrance, and has 35,000 square metres of space for Belgian exhibits, and at right angles, under the same roof, 15,000 square metres reserved for the exhibits of the United Kingdom.

Since visitors passing from the main entrance to the other sections and to the Machinery Hall are bound to pass through it, the United Kindgom has thus secured what is really the best position in the whole exhibition, and great credit is due to the British Commission for insisting upon this particular site.

Previous to the opening, the new exhibition's branch of the Board of Trade held provincial meetings, at which addresses were delivered by the Earl of Lytton and Sir Swire Smith, chairman and vice-chairman of the commission, and by Mr. U. F. Wintour, the British Commissioner-General.

Subsequently individual firms were canvassed and it was found that both among British manufacturers and traders much discouragement had been caused by the superior policy of France, Germany and other countries, where permanent organizations for the care of exhibitors' interests have existed for years. The evidence taken by the departmental committee showed a widespread disposition to cease exhibiting, even in trades which had everything to gain by the effective display of their goods abroad. It showed also that the national reputation was suffering as the effect of inadequate displays.

King George, then Prince of Wales, as president of the Royal Commission, made a powerful appeal for a special national effort, and it is very gratifying to see that many firms have taken up space and have gone to considerable expense without any heed to individual gain. The British section is essentially one of collective exhibits. Public spirit and

foresight have prompted exhibitors to forego their individual rivalries and combine in powerful and attractive displays which will add considerably to the national prestige. Foremost amongst these are Huddersfield and Bradfield and South of Scotland textile trades, which have made a show never surpassed in any international exhibition.

The significance of such enterprise is greater than at first sight appears. Patterns for the markets are designed many months in advance, therefore textile exhibitors cannot show their newest goods without risk of having them copied, and hence the British textile trades have not until now shown to their best advantage at exhibitions. The purpose of their collective exhibits is, for this reason, to be distinguished from that of the exhibits made by many firms in other trades who may hope to book orders for what they actually show. We may say here that the altruistic policy has probably been carried too far. We see the most dainty costumes in woolens so fine as to be mistaken for silk, men and women faultlessly dressed in British-manufactured materials, yet absolutely no indication is given of the names of the many manufacturers who contribute to those exhibits. This question of inadequate representation is the most impressive feature of the British section. Utterly incomprehensible as it may appear, we have at this exhibition various groups, as well as a number of individual manufacturers, all presumably sane and competent business men, who at very considerable expense and trouble have produced some of the handsomest shows of their goods ever seen anywhere, and yet deliberately cut off all chance of profiting by it. Huddersfield had a man on the spot, but the local representative is the exception and not the rule, and the *intelligent* representative who combines a knowledge of his firm's exhibits and the art of making them known, together with the necessary linguistic capabilities, is a *rara avis* indeed. In the case where as many as fifty firms have combined, a small weekly contribution would have sent either a couple

PRINCIPAL FACADE, BRUSSELS EXPOSITION

of good men for the whole time, or employees of each firm for a fortnight each, who would at the same time have learned much to benefit themselves and the firms they represented.

Inquiries have shown that where adequate representatves are to be found on the stands many important orders are being booked. Labels on most exhibits are either printed in too small a type or are not translated, when the people have taken the trouble to provide any at all, and in many cases exhibitors have been content to let the excellence of their goods speak for themselves without giving visitors an indication what they are now and where they are to be procured. These good folk will probably blame everybody but themselves if they find their outlay unremunerative.

To resume. The collective exhibits of Huddersfield and Bradfield comprise two dozen admirably arranged panoramic tableaux, with backgrounds painted by Mr. Walter Hann. Here the whole process of manufacturing woolen goods is shown, starting from the sheep tendered by the shepherd and passing through all processes of manufacturing until finally we come to garden parties, evening receptions, the House of Commons lobby, etc., filled with models wearing the latest Paris and London fashions. The machinery in the foreground, and even the actual tools, baskets, and the clothes worn by the factory hands, have been brought over and used in these illustrations.

Other collective shows include a most artistic stand by the Fine Cotton Spinners and Doublers' Association, an amalgamation of fifty-two firms, who are represented by a symbolical group of statuary of weavers and spinners. In the silk trade, five firms in London and four at Macclesfield are showing together for each of those centers.

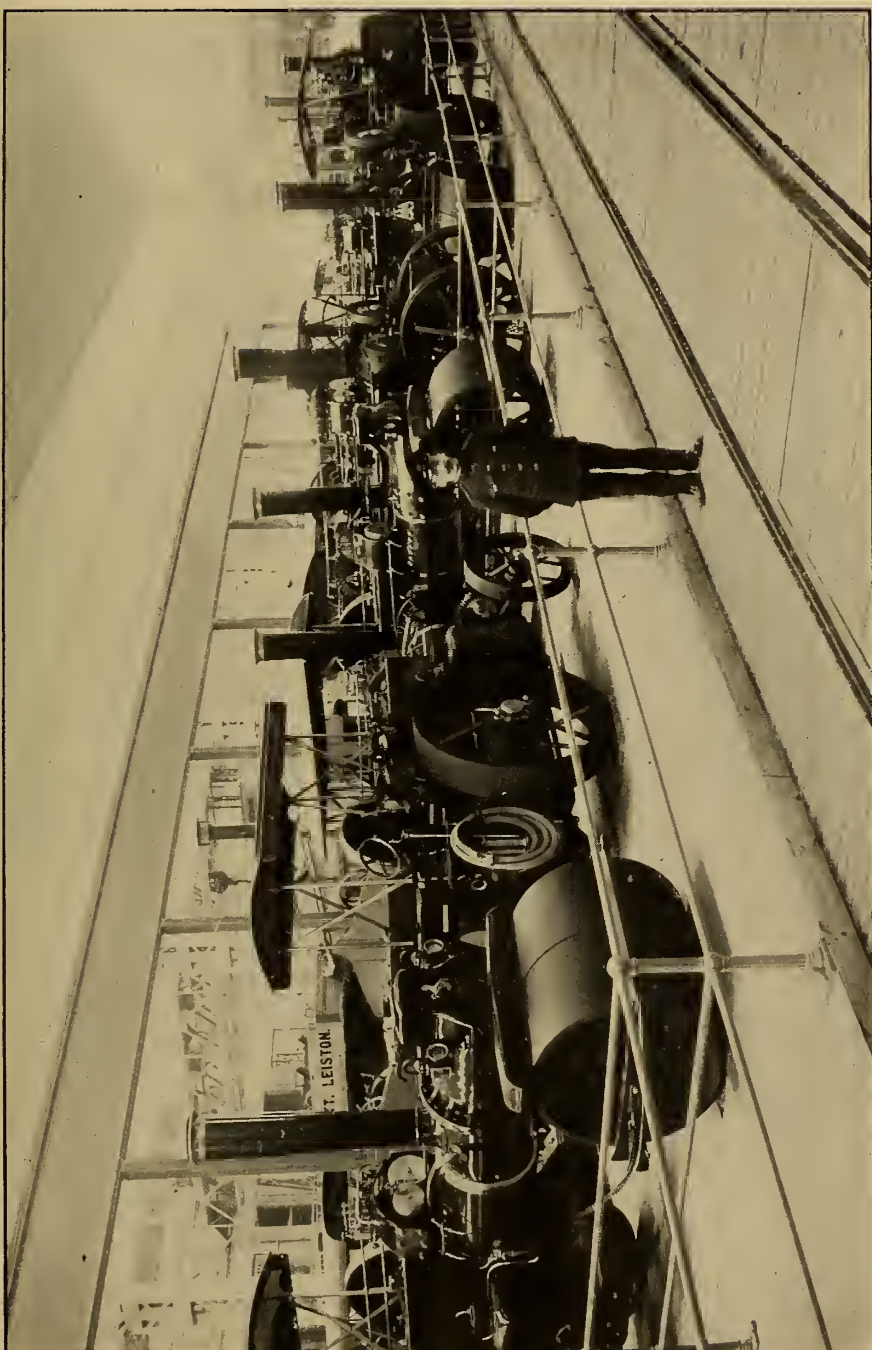
An exhibit arranged by the Board of Agriculture calls attention by means of photographs to the paramount position of English pedigree stock.

The home-office exhibit of models and illustrations from the factory, mines and explosives department is especially appropriate, as Belgium is essentially a mining and manufacturing country. It includes many novel devices for the safety, health and rescue of workpeople engaged in dangerous operations. With regard to effective display, the home office has led the way. Their exhibit is well arranged; each object has labels in three languages, and there is an efficient representative. Their models showing the training of miners, the researches for the prevention of dust in factories, etc., gives a thorough and exhaustive picture of an enormously useful work, and they are amongst the best that are to be found in the whole exhibition.

A great variety of the most highly-finished philosophical, mathematical and scientific instruments unsurpassed in finish and detail elsewhere, will be found amongst those left to blush unheard by the wayside.

A small display of motor cars and chassis has been arranged by the Society of Motor Manufacturers and Traders. The exporting collieries of the northeast coast, the principal colliery companies, railways and others, who can only derive a very indirect advantage from their outlay, have most interesting, and in cases very large, exhibits of models and installations, which are very attractive to visitors.

In arranging the contents of the Industrial Hall it was found possible to obtain some of the effect of collective exhibiting by grouping individual exhibitors. The courts devoted to carpets and to modern tapestry, the attractive suite of courts illustrating English furniture, an important group of fifty-one cases of ceramics, the court of chemical industries, are well arranged on this principle.



TRACTION ENGINES AND AGRICULTURAL MACHINERY, INTERNATIONAL MACHINERY HALL

A similar policy was pursued in the International Machinery Hall. The most important groups are machine tools, agricultural machinery and cotton and flax spinners. We are indebted to the Royal Commission for the use of the three splendid photographs illustrating these three groups in the present article, the scope of which does not permit to enter into the description of particular exhibits.

EXHIBIT OF BRITISH COTTON AND FLAX SPINNING MACHINERY IN THE INTERNATIONAL MACHINERY HALL

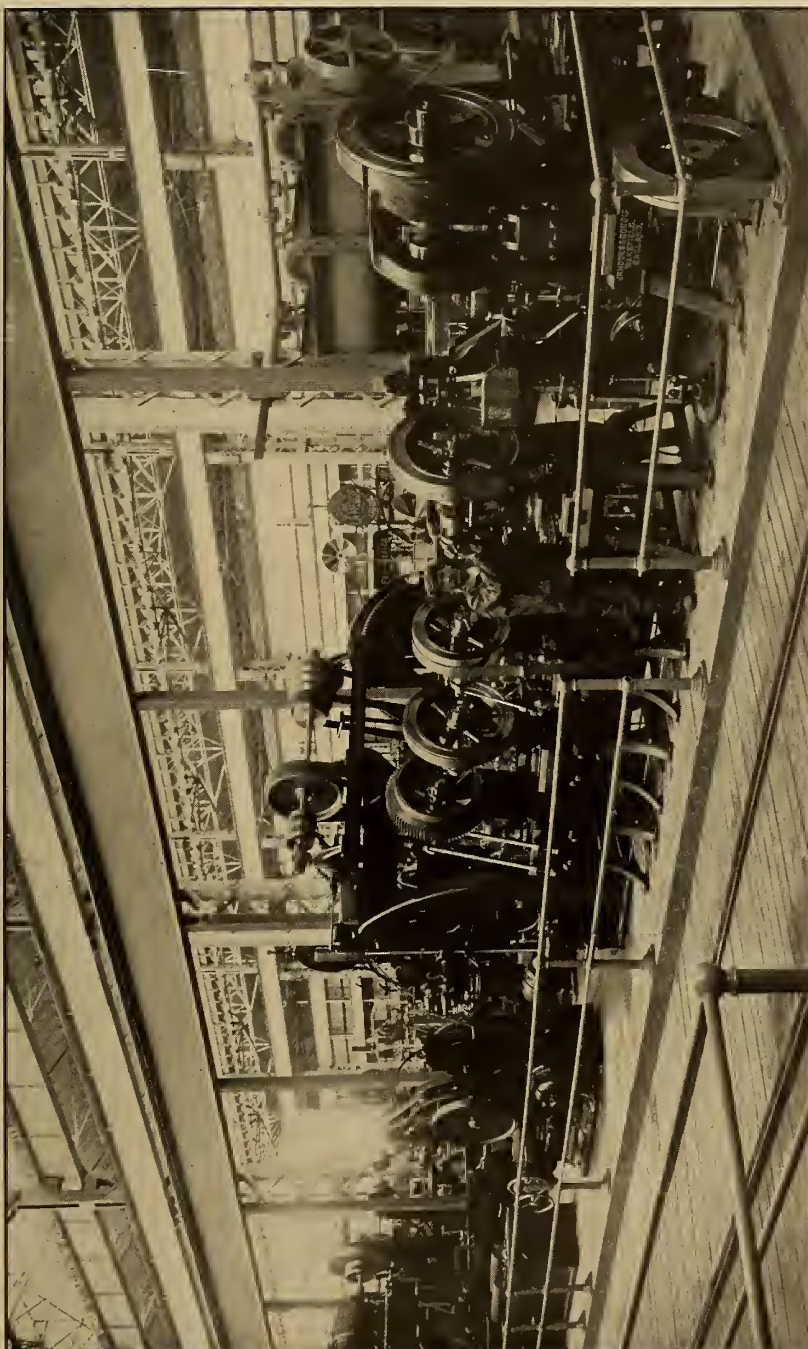
The British Commission, actuated by the best of motives, viz., that of giving their exhibitors as much space as possible, with retiring modesty have stowed themselves away in a humble corner in offices as difficult to find as they are insignificant in size and decoration. Other countries have given more consideration to prestige in this respect, and the lofty, almost palatial, chambers, hung with magnificent tapestry, handsomely furnished with carved old marble and gilt tables and chairs, resplendent with tall gilt mirrors, reaching from low marble consoles to the high, well decorated ceilings, the wide folding doors leading to spacious offices, etc., of their Commissioners make the primitive British arrangement, which has "temporary shed" written all over it, look very insignificant indeed.

The architecture of the British section (by Humphreys, Ltd.) within the Industrial Hall is in a pure Corinthian style. The white-fluted columns with Jupiter Stator capitals are 23 feet 6 inches high; the archway of the entrance is 38 feet high, 18 feet wide and 15 feet deep; measured to the top of the blocking course, its height is 48 feet.

The staircase at the head of the hall leads to a floor 20 feet higher than that of the hall itself.

The courts of Canada, France and Italy may be, in fact are, more rich in colour and more gay in the style of the decorations adopted. Yet the pure white of the British section has a cool, elegant effect which is both artistic and pleasant in the highest degree.

Exhibitors have been relieved of



BRITISH MACHINE TOOLS IN THE INTERNATIONAL MACHINERY HALL, BRUSSELS

all care with respect to decoration, which was arranged by the exhibition's branch on the advice and help of Mr. Charles Allom and Mr. Frank Warner, members of the Royal Commission. A uniform design of show-cases has been adopted throughout.

The International Machinery Hall further contains a large number of fine machine tools from the United States, two complete sets of sugar-mill plant from Holland and many large exhibits from France, Italy and Austria. On most of the British stands too many machines have been crowded together, while foreign firms have been content to show one large unit in actual working. A splendid distributing switchboard, with about two dozen marble panels, is installed along the whole width of the hall.

Further electrical and other machinery will be found on the magnificent Palais du Génie Civil and in a smaller hall devoted to collected electric exhibits. France has also a special engineering section with notably some up-to-date artillery. The Belgian, German and other railway exhibits, which are of the greatest interest, are to be found in separate halls.

The Belgian Arms Factory also has a separate building. The importance and variety of the Belgian section may be gauged by the fact that they occupy about 60,000 square metres; it would take a book to describe them.

The United States and France occupy about 50,000 square metres, and about 30,000 square metres are divided amongst Italy, Switzerland, Portugal, Turkey, Japan, Denmark, China, Uruguay, etc. The Italian court is crowded with statuary and most gay and joyous in effect. The French is more delicate in colour and, upon a cream foundation, well represents the characteristic features of French decorative art. Every branch of industry is well represented. In the Spanish section we have a reproduction of the Court of Lions in the Alhambra, poor and tawdry if compared with the small, but exquisite, reproduction erected at the Crystal Palace at Sydenham.

An idea of the large amount of material used may be gathered from the fact that 3,700,000 kg. of iron and steel, 30,000 square miles of glass, and 50,000 square metres of zinc were used in the construction of one section covering 51,500 square metres of ground.

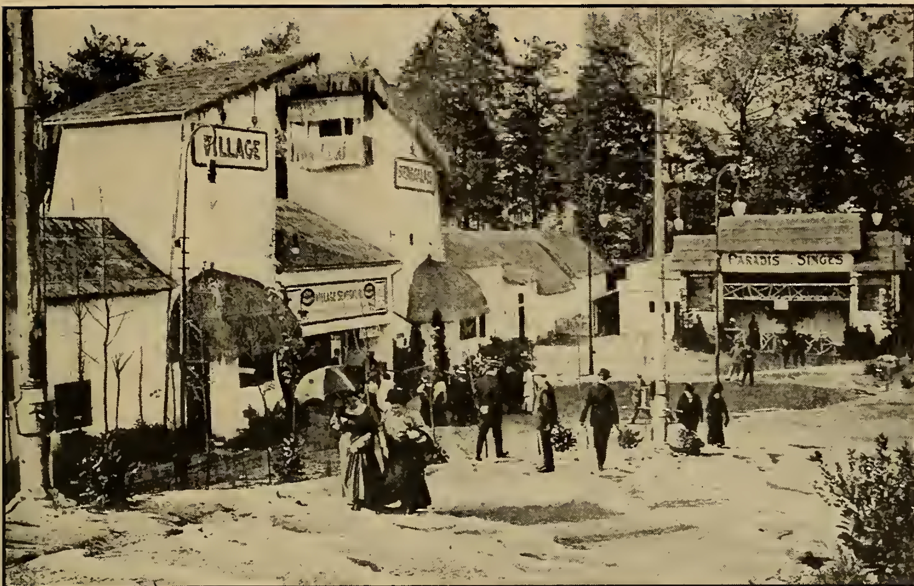
The Machinery Hall is really one-third of a large building, of which it occupies 30,000 square metres. A platform raised 12 feet above the ground runs the whole length and part of one side of it. By these means visitors have an uninterrupted view of the machinery exhibited, most of which is to be shown in motion. This gallery is an innovation which will be much appreciated, as generally visitors on the ground floor experience great difficulty in obtaining a satisfactory view.

An annex to the Machinery Hall is set apart for the generating station, in which a 15,000 horse-power plant supplies most of the motor power for the whole of the buildings.

The chimney for this station is 60 metres high. It has a ferro-concrete basis 6.34 metres high, of which 4 metres is underground. The double hexagon of the stack is formed of concrete blocks, which were cast on the ground.

A small sub-station near the entrance to the grounds, fed by the town supply, provides the current for lighting the grounds and buildings.

The foundations of the Railway Hall were constructed on a novel and rapid system, which combines great stability with economy, as there are no excavations and no carting away of material. The method, as its name—compressol—indicates, is based on compressing the ground for the pillar foundations. A movable scaffolding consisting of a light iron frame and a 5-horse-power motor drives a carrot-shaped iron ram into the ground. This wedge has a



THE SENEGAL VILLAGE AT THE BRUSSELS EXPOSITION

circumference of 3 metres, 50 on the top, and runs almost to a point at the bottom. When a round hole of sufficient depth has been made by the repeated impetus of this wedge (in this case the operations were carried on on filled-in land) about 6 metres 50 concrete is thrown in. Then eight iron staves with half hoops at the end are let into the hole; a conical wedge with rounded ends is substituted for the carrot, and the hole is enlarged to 1 metre 50 circumference. Finally, about 0.50 metre are cut square to 1 metre 20 (but not excavated) rammed concrete is put in, four small, round iron sockets are let into the concrete, and the base for the pillar is complete. Sometimes as many as four of these bases were completed by one machine in a ten-hour day.

The whole of the main buildings and pavilions form an oblong square, in which various countries have laid out gardens in their own distinctive styles. Between two other sets of gardens on the east side of the grounds a large space is set apart for side shows and other attractions. These are all under an American syndicate, and comprise every motion in queer movement that has been devised. They include the Senegal Village, La Royaume Mervielleux, Creation, Dip the Dips, Wild West, Witching Waves, Great Scenic Tree, Le Tickler, Mountain Slide, Figure Eight, Miniature Railway, Water Bumps, La Roué Joyeuse, La Maison Joyeuse, Rifle Ranges and Oleorama.

Crossing the Avenue de Pesage on one of the numerous bridges, which are of unusually solid construction, as they have to bear a double track of tramways—wood and iron or ferro-concrete being employed in their construction—the Colonial Gardens are reached. Here are various separate buildings, such as the Palaces of Arts, Colonies, Water and Forests, a dairy, lace manufacture, etc.

To the right of the gardens, facing the main entrance and along a street east of the main hall, a number of the most interesting national and municipal pavilions will be found. The town of Brussels has constructed a large house in the Seventeenth Century—so-called Louis XIV. style—reminiscent

PAVILION OF THE CITY OF BRUSSELS

of the guild houses surrounding the famous Grande Place; in the interior statistical information as to municipal engineering is shown. The construction shows a corner tower, 50 metres high, surrounded by a figure 6 feet high; nine large, beautifully-executed figures ornament the sides of the house.

The Antwerp pavilion is an exact reproduction of the well-known Rubens House.

Ghent reproduces the beautiful guildhall of the Masons and part of the Achter-Sikkel.

The *salle des fetes* of the modern exhibition design initiated at Paris contains seating accommodation for 4,000 people. The pavillion of the Netherlands is an imposing structure in rich Dutch renaissance.

The United States exhibits are divided between two sections; the largest space is in the Halls of Industry and consists of exhibits of manufactured articles of merchandise. The smaller space is in the Machinery Hall, and contains, as already mentioned, some of the best working machinery in the exhibition, reflecting great credit upon the companies participating. Principal among these exhibitors are the Brown & Sharpe Company, Pratt & Whitney, Ingersoll-Rand Drill Company, American Pulley Company, Cincinnati Shaping Company, Cincinnati Milling Machine Company, Alfred Schutte & Co., Schieren Company, Forderer Company, Miller Du Brul and Peters Company.

In the Halls of Industry the United States has taken a section which has an area of about 22,000 square metres. We find the American typewriter companies very strongly represented, having such companies as the Remington, Underwood, Smith and Yost typewriter companies.

The Singer Sewing Machine Company has taken the largest space of any firm in the United States section and have installed a very interesting and comprehensive display. Other firms in this section are Yale & Towne Mfg. Company, Bissel carpet sweepers, Walkover shoes, Fenwick Bros.' Graphic Arts Company, Cheesman Optical Company, American Optical Company, Reece Buttonhole Machine Company, Aluminum

Goods Manufacturing Company, Heywood Bros., Wakefield Company, Dorman Vulcanizing Machinery Company, and many other representative lines of American manufacture. The large entertainment grounds, where, as previously detailed, mechanical motion in all its aspects is being made to contribute to the amusement of great crowds, are entirely in hands of Americans.

We may here note the United States Government decided not to participate officially in this exhibition, although an urgent recommendation to do so was made by President Roosevelt, but Congress refused the desired appropriation. Then the Brussels authorities appointed Professor J. H. Gore, of Washington, D. C., as commissioner to arrange exhibitors, in co-operation with Mr. Paul Grosjean, of Brussels, in the interests of American exhibitors.

A New York office was opened in charge of Mr. Otis S. Chessman, to take up the matter of collective exhibits, Mr. Frank Strauss dealing with American companies in London. The United States Government, although not participating, later took official recognition by appointing Mr. John Ball Osborne, Chief of the Bureau of Trade Relations, as "Honorary Commissioner General," and Mr. Hugh Grant Smith, Secretary of American Legation, as Honorary Commissioner.

The exhibition railway branch, which brought in the goods, landing in a bottle-neck, much delay was caused. Germany had its own line right into the section, and theirs was the only section which was completely ready for the opening. The government of that country not only erected its own halls, but made itself further independent by providing its own central station, equipping it with exhibitors' plant and supplying current for light and power in the whole section. At a meeting of German manufacturers held in Dusseldorf in 1908, it had been decided to abstain for five years from all participation in foreign exhibitions, but at the instance of the German Minister for the Interior this rule has been released.

The organization, planning the execution of this comprehensive scheme, which was begun three years ago,

ITALIAN PAVILION AT THE BRUSSELS EXPOSITION

was carried out through the Engineering Commission of the German Government, by the Chief Engineer, Mr. F. Fritsche, whose thoroughly successful work at the Dusseldorf Exhibition in 1902 and 1904, and at Nuremburg in 1906 has proved him an expert in exhibition engineering.

Germany is housed in a separate building, covering over 30,000 square metres, with an exceedingly heavy framework carrying several transporter bridges.

The space of the section is divided into separate halls as follows: General Industries Hall, 6,500 square metres; Principal Machinery, 5,700 square metres; Power House, 2,600 square metres; Boiler House, 7,500 square metres; Engineering, 1,800 square metres; Agricultural Machinery, 1,800 square metres; Railways, 2,800 square metres;; Art and Applied Arts, 3,000 square metres; Pavillions and Cafés, 2,500 square metres. The principle underlying the German section, which has been thoroughly carried out, is to group together each branch of engineering so that visitors may find on one spot all machinery required in one particular industry.

Thus we find in the principal hall the following groups: Mining iron work, rolling mills, metal working machinery, woodworking machinery, leather working machinery; printing and paper textile industry, etc. Agricultural machinery and refuse destruction are to be found in another hall and annex, which contains laundry machinery. Special sectional catalogues, printed in various languages, are provided.

The power house contains the dynamos, engines, pumps, compressors and armatures. They consist of a 10,000 horse-power steam turbine direct coupled to a rotary current generator (Bergmann), a 2,250-horse-power steam turbine direct coupled to a rotary generator, and a small 150 horse-power steam turbine direct coupled to a continuous current generator of the same make. A 1,000 horse-power locomobile (Lanz) direct coupled to continuous current generator (A. E. G.), a 600 horse-power locomobile (Wolf), with a transmission belt to a C. C. generator (Lahmeyer), a (revolving piston), steam engine, 250 horse-power (International Hanover) direct coupled to a C. C. generator (Pöge), and a 30 horse-power suction gas motor used for starting a C.C. dynamo. Another group contains a 1,000 horse-power ship engine (Lenz steering), several small locomobiles and a gas motor aggregating 425 horse-power, several 15 horse-power Diesel motors, and a 100 horse-power locomobile, making a total of 21,000 horsepower. There is a twin boiler of 500 square metres heating surface and tubular boiler of 300 square metres, and a cooling tower with a capacity of 500 cubic metres per hour. Besides centrifugal pumps, electric motor-driven, there are feed-water and cooling water pumps. The steam and other fixing is by the Gesellschaft fur Hochdruck-Leitungen, Berlin, who have also fitted the piping for the International Section. The main switchboard is of the most modern construction and equipment. The cables for the German section were delivered and laid ready for supply by the Kabelwerk Rheydt, and we understand that the same firm has supplied the whole of the cables for the rest of the exhibition. A fully equipped controlling box enables the engineer by the use of numberless apparatus, all exhibits, to tell at a glance the working of each unit in this section.

The educational sections are full of the minutest details. Very comfortable reading rooms, filled with the exhibit of publishers of books and periodicals, are provided for the use of visitors. About fifty handsome rooms, specially designed and fitted and furnished most luxuriously, illustrate the building, designing, furnishing and decorating trades. No tickets are on these exhibits, but a neatly framed tablet is placed at the entrance of each room, giving all

the particulars and necessary information.

Next in importance as a single exhibit comes undoubtedly the pavilion of Canada. Rich in colour as far as decoration is concerned we find here collected all that the colony produces and the amenities to the settler are indicated by exhibits of game and fish modeled in life-like resemblance. A large group of agricultural machinery manufactured in the Dominion occupies the centre of the hall. No names are given. Opposite, in a fine, white Ionic temple, the Grand Trunk Company gives free cinematagraph displays of Canadian scenery.

The French show a number of buildings of the style in use in their colonies across the seas, and an imitation of an Indo-Chinese temple, which, in its vivid red colouring, stands out a prominent feature.

In various parts of the grounds are refreshment houses, built in the style of their respective countries, where national dishes and beverages are dispensed.

A square, formed of old German houses, grouped around the interior of an immense covered hall, makes a cool retreat during the hotter hours of the day.

Apart from the "American Amusement Park" already mentioned, which represents an immense outlay of capital, brains and energy, and is wholly financed by American capital, there is the Brussels "Kirmess" or Fair, near the main entrance. It consists of 108 houses in the XV and XVI style, reproductions of actual buildings. The interiors are utilized for cafés and sideshows.

Large grounds are reserved for sports, of which balloon and flying machine ascents of an international character will be a main feature. Amongst the prizes are some of £2,000 for the three best flights from the Exhibition to Antwerp, around the cathedral there, and back.

METHODS OF LAYING OUT CITIES

By Charles W. Barnaby

THE enormous aggregation of masses of the people in great cities has made it necessary for the thoughtful engineer to consider the principles which should be observed, either in laying out the plan of a proposed city, or the correction of the defects of such cities as have become so crowded as to be in need of revision and partial reconstruction.

The principles involved in such a problem are necessarily influenced by local conditions, but there are certain features which may be examined as bearing upon certain places which have already become critically acute in their relations to the people who dwell within their limits.

In the first place, cities, instead of being built in continuous solid masses, should be divided into comparatively small sections by parks and parkways, especially for protection against disastrous conflagrations. Such an arrangement would also provide park and transportation facilities, and also furnish ducts for the entrance of fresh air to the interior parts of the city.

In the second place, in cities such as New York, in which there is a deficiency in avenues of travel in any given direction, some of these parkways should be utilized for subways, auto tracks, carriage drives, etc., without involving grade crossings for the transverse streets.

In New York, for example, there are practically no avenues of travel whatever suitable for automobiles in the lower, or business part of the city.

To carry out such plans in cities already built and crowded would involve enormous expenditure, but some such improvement is rapidly become an absolute necessity, and the expense required at the present time is but a fraction of that demanded in the course of a few years; while if the improvements are made judiciously while there is yet time there will be a handsome profit accruing to the citizen who is sufficiently far-sighted to acquire the property abutting on the line of the obvious improvements.

Although the principles of what follows may be applied in general to nearly every large city, the author has taken New York as an example of what may be accomplished in the improvement and development of a great city.

As has been pointed out at various times, a grave mistake was made in laying out the plan of New York, since the streets above Eighth street, running lengthwise of the island of Manhattan, were placed too far apart.

This was doubtless due to the fact that the founders of the city assumed that the natural lines of longitudinal travel would be the two rivers on either side of the long and narrow island, and that it was most desirable that ample opportunity should be given to reach the water at any point. The closeness of the cross-streets, running east and west, is ample demonstration of the fact that the rivers were considered as offering the best lines for travel, and if the avenues running north and south had been placed as close together as the cross-streets there would have been about forty in number, instead of fifteen, as at present.

These are only single examples of the defects which would be avoided if complete cities could be carefully designed and built by engineers under rigid specifications. Under such circumstances city building would have long since been reduced to an artistic and utilitarian science, with its specialized city designing engineers and a full line of engineering literature relating to the subject. As it is now, what is said and written on the subject is frequently more the product of idle thought and conjecture than the result of scientific investigation and practical experience in the art.

The field of city design is too large for any one person to master in all of its details, and the office of the city designing engineer should include a corps of experts covering practically all of the various branches of art and engineering.

If a complete city ready for the occupancy of four or five million people and accompanying business interests could be thus designed and built under the supervision of such competent expert and corps of specialists, particularly if they could have some latitude in regard to the selection of a suitable site, the results in the way of health, comfort and convenience, as well as in artistic appearance of the product should be gratifying.

The ideal city should be laid out with carefully selected sites for public buildings, schools, colleges, churches, amusement halls, residential areas, business houses, factories, interborough transportation lines and passenger and freight terminals; also docks, bridges, ferries and tunnels, when water courses enter into the problem; and along with all the rest the matter of the distribution of parks and parkways requires judicious consideration. All of the above should be located in such relation to each other and the surroundings as to provide the people with the safest, most convenient, and most satisfying accommodations and, at the same time, present a highly pleasing and artistic appearance.

The large parks should be in the outskirts and should be left in as natural a state as practicable with their native forest trees. Such paths and lanes as are required, with their bridges, resting nooks, etc., should be judiciously treated to conform, as far as possible, with the natural surroundings. The parks throughout the body of the city, instead of being large and few in number, should be of medium size, plentiful, well distributed and connected, together with numerous parkways of liberal width. This arrangement would give all parts of the city convenient access to the park spaces, which, being thus arranged in a continuous system, could, when once entered, be traversed throughout without leaving it, if desired.

It is an unfortunate fact, however, that cities, as a rule, are not built to order, but, like Topsy, just "grow'd," without any consideration, or conception, even of the possible or probable future requirements. As a result, most of the cities depart widely from the ideal; the narrow and poorly arranged streets, scarcityof parks and parkways and restricted transportation possibilities all have their detrimental effect, while such things as barriers against destructive conflagrations are conspicuously absent, both to sight and mind.

The destruction of life and property by great fires has been something appalling, and yet, immediately after a city has been visited by such a calamity, it is rebuilt in the same compact mass in utter disregard of the forcible demonstration it has just given of the need of some preventative measure against a recurrence of the disaster.

Under certain possible conditions, the whole of Manhattan Island might be burned over from the Battery to 155th street, with a possibility of also laying bare sections of the Bronx and Brooklyn.

Among the fires entailing a loss of

$10,000,000, and upward, in less than two and one-half centuries past may be mentioned London, 1666, $33,650,-000; Smyrna, Turkey, 1772, $20,000,-000; Constantinople and suburbs, from 1729 to 1870, a dozen fires ranging from $10,000,000 to $25,000,-000 each; New York, 1835, $17,500,-000; Hamburg, 1842, $35,000,000; Charleston, S. C., 1861, $10,000,000; Portland, Me. 1866, $10,000,000; Chicago, 1871, $165,000,000; London, 1874, $70,00.000; St. Hyacienthe, Que., 1876, $15,000,000; St. John, N. B., 1877, $15,000,000; Kingston, Jamaica, 1882, $10,000,000; St. John's, N. F., 1892, $25,000,000; Guayaquil, Ecuador, 1896, $22,000,-000; Ottawa, Ont., 1900, $10,000,000; Baltimore, 1904, $50,000,000; Toronto, 1904, $12,000,000; and last, but by no means least, San Francisco, 1906, $350,000,000, or more, and yet it has been rebuilt in the same old way. There have been many other fires of less extent than the above, but which have been, nevertheless, of serious proportions.

Is it not time to give this matter of conflagrations serious attention and to take some measures to cope with this terrible menace to our lives and property? Terrible as the past record has been, the conflagrations of the past are insignificant as compared with what may, within the range of possibilities, occur under present conditions in some of our largest cities.

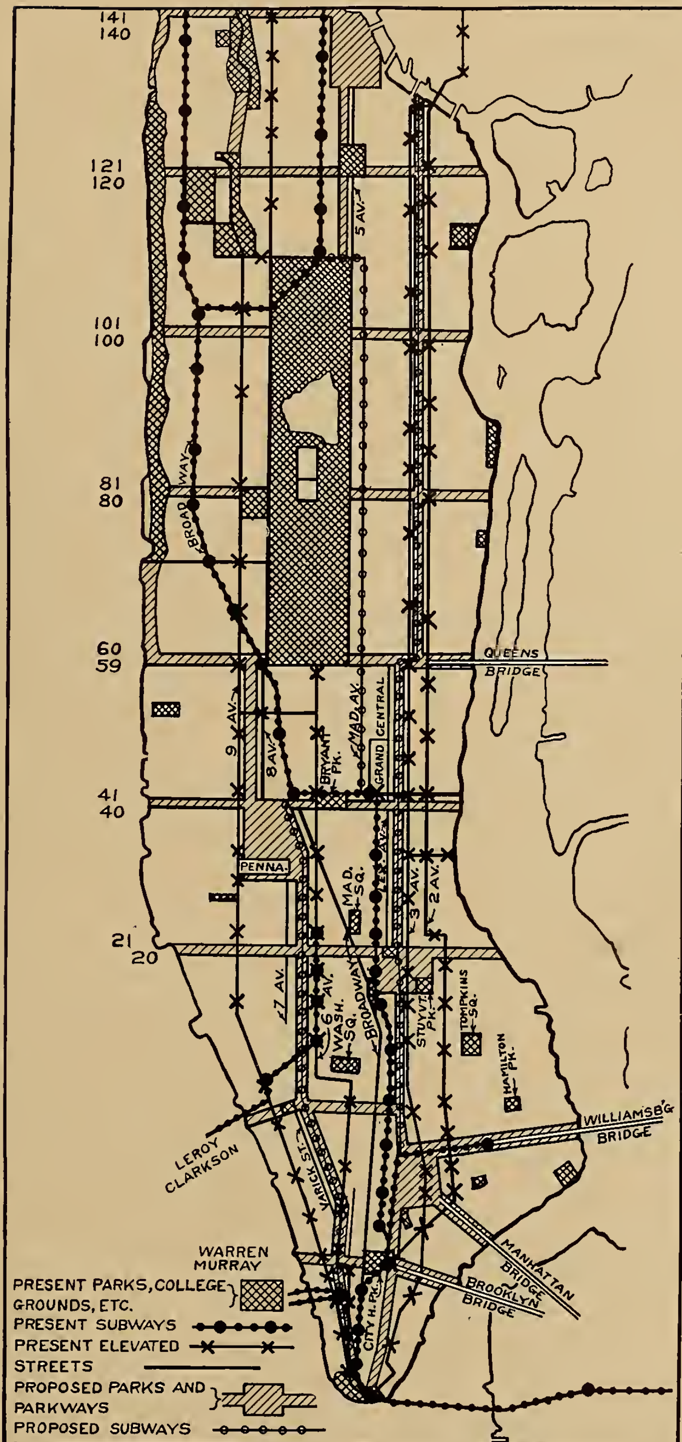
It is a sin bordering on a crime to continue to construct cities extending over miles of territory in dense formation, without incorporating effective means for cutting off the course of a conflagration after it has escaped ordinary bounds and restraint.

Cities should be divided into sections not exceeding one mile square by parks and wide parkways; these will not only serve as fire barriers, but will add greatly to the health, comfort and happiness of the people and the beauty of the city. This system provides a break in the continuity of the building mass, thus making it practically impossible for a conflagration to spread over miles of territory before checked. It would be much easier to stop a fire at the parks and parkways than in a solid mass of buildings. The cutting down of trees and shrubbery would be much easier, safer and more effective than the destroying of a line of buildings, and the loss of a mile or two of the parkway's adornment would be a trifling matter in comparison with the loss which would be caused by the destruction of an equal area of buildings.

Another important office of the proposed park and parkway system suggested for New York would be to protect the great bridges. The space under, and for some 200 feet each side of the bridge approaches, should be included in the park space and should be free of buildings. A comparatively small conflagration along that part of the East River containing the approaches of the Williamsburg, Manhattan and Brooklyn bridges might destroy all three of these bridges. In such a case the loss to the people in business, time and situation would probably be greatly in excess of the actual money value of the destroyed bridges. The large public buildings should be protected in the same way, and all future schools, etc., should be located along the line of the park system.

Although cities cannot be built to order to definite ideals, much can be done to improve those that have been handed down to us. Opportunities should be watched for to correct faults already incorporated in their make-up, and plans formulated and suitable regulations adopted to improve them along proper lines.

Laws should be passed which will prevent any further growth of cities and villages without proper provisions for suitable parks and parkways. It should be provided that no village or city extending one mile or more in either direction should be further extended without being separated from such extension by means of a parkway of not less than 300



SUGGESTED IMPROVEMENTS IN NEW YORK CITY

feet wide; also that they should not extend their boundary line up to that of an adjoining village or city without providing a parkway 300 feet or more in width along the dividing line between them.

The various conditions and surroundings of different cities call for different treatment in each case, Manhattan, for instance, being long and quite narrow, does not have the same necessity for diagonal streets that a city would that extended unbroken in all directions. While a few diagonal streets leading from important gates of entrance and from important centers could undoubtedly be placed to advantage in a newly designed New York, it is a question whether the advantage would be sufficient to justify incurring the expense that would now be involved on account of having to destroy much valuable property to accomplish the purpose. As for the gates of entrance, it is a question whether it would not be more practicable and satisfactory to distribute the throngs outside the confines of Manhattan by providing the diagonal thoroughfares on the other side of the rivers, where there is more room and property is less expensive. Those coming to or leaving the city could then pass through the gate nearest to their point of destination or location in Manhattan and would have no necessity to make a diagonal cut across the city.

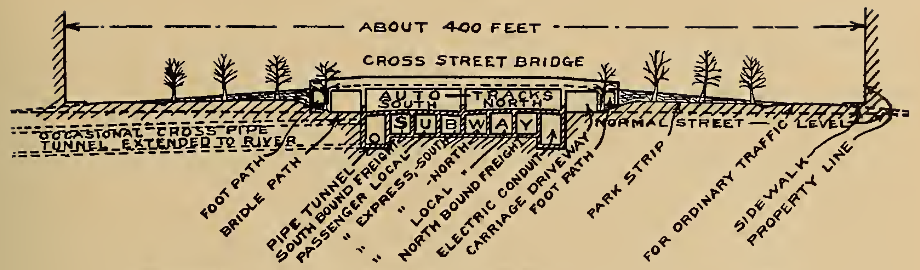
An important feature of the generous application of the parkways scheme is that in addition to the value for recreation and protection against conflagrations, the parkways form much needed ducts for the ingress of fresh air currents into the body of the city, thus adding greatly to its health and comfort.

The need of more north and south avenues of travel on Manhattan is real and pressing and is becoming more urgent every day, particularly since the advent of the automobile. Automobiles have come to stay. They have come fast, and they will continue to come even faster and must be provided for accordingly. There is to-day absolutely no suitable avenue of travel for these vehicles in lower New York, and the uptown avenues fall far short of the requirements in this respect. It should be so that owners of automobiles in uptown and outlying districts could get to and from their places of business in lower Manhattan with comfort and dispatch. If such proper facilities for automobiles were available many would avail themselves of that course of travel, which would help greatly to relieve the congestion on public transportation systems.

Aside from the demands of the automobile, there are the rapidly increasing demands of these public transportation systems, which it is going to be difficult to meet with the restricted northward avenues.

Transportation and other problems related to "The City Beautiful" are receiving more attention of late than formerly. Considerable practical work has already been done or is under way, various schemes have been proposed, and some have been approved for future application, but any plan which fails to recognize and provide for this growing need for additional avenues of travel in a north and south direction will fall woefully short of meeting the necessities of the case.

It is rather late in the day to consider a radical remodeling of New York, but there is a great deal that must be done and much more that might be done to greatly improve the city in the way of utility, health and beauty. The accompanying map is presented as one suggestion for an improved New York. While the changes indicated would be too great to be carried to completion at any early day, if some such scheme could be decided upon, all future improvements could be made with that end in view; and, with possible occasional donations and bequests from persons interested in the plan, and the assistance and incentive



PROPOSED STREET ARRANGEMENT

possibly of a few conflagrations, which would eliminate the necessity of purchasing valuable buildings which are now in the way of the proposed parks and parkways, the ideal might in time be closely approximated.

Tremendous as the expense would be, it is a matter for serious consideration as to whether it is not becoming an absolute necessity. If so, the sooner that fact is recognized and the plans formulated, the less the expense will be, as at present the greater part of the proposed route is now occupied by old, comparatively small buildings, which will soon be replaced in a large part by expensive modern buildings.

It will be noticed on the map of New York that two north and south parkways are provided for, both leading from Battery Park to the upper part of the city, one on the east and one on the west sides. These parkways being cut through the blocks between present avenues, except in places through the lower part of the city, add greatly to the facilities for travel in their direction.

The cross-section view of these north and south parkways gives a good idea of their value for facilitating travel and for recreation, fire protection, etc. The subway system in the center consists of the usual two express and two local tracks, with the addition of two extra outside of these for light freight, baggage, packages and mail transportation. Such a subway goods transportation system would greatly facilitate business and relieve the congestion of the regular street traffic by doing away with many of the delivery, express, baggage and mail wagons. Outside of the subways are pipe and electric tunnels, and over the whole are the automobile tracks. Outside of these are the carriage driveway, bridle path and foot paths, all of which are bridged over at the cross streets, so that grade crossings are avoided, and reasonably fast speed can be made by the autos, carriages and horsemen without danger. Along each side are the park spaces and ordinary roadways and building frontage.

The cross street bridges might first be placed at every third or fourth street, and the intervening bridges added later as traffic demanded.

This full width scheme could probably not be carried farther down town than to Houston or Franklin street.

The proposed west side subway goes only as far uptown as Forty-second street, where it connects with the present Broadway subway system and eventually becomes the southward extension of that system. The west side parkway, however, extends farther uptown, terminating at Fifty-ninth street. North of this point street traffic is reasonably well taken care of already, and can easily be supplemented by constructing straight driveways through the west side of Central Park and extending Riverside Park and Drive down to Fifty-ninth street, as indicated on the plan.

The east side parkway extends

from the Battery to the Harlem River and its subway system extends from the bridge connecting subway at the Queensboro Bridge to the Harlem River.

By extending the downtown end of the present subway from Forty-second street up Madison avenue to 110th street, and there connecting it with the Lenox avenue line, the Broadway line already having been carried south from Times Square, we now have the Lenox avenue line and the Broadway line extending in entirely separate systems all the way from the Battery to their northernmost terminals, but connected at the Battery, Forty-second street and Ninety-sixth to 110th street by shuttle railways.

These two systems, supplemented by the one along the proposed east side parkway as described above, make three separate subway systems to northward extremity of Manhattan or beyond, and these may, when necessary, be farther supplemented by utilizing more of the wide parkway space for the purpose, and still farther by placing another system of subways beneath the first, thus double-decking the entire system, if necessary. Under such conditions it is not probable that the demands will ever exceed the possibility for extension provided by the proposed plan.

The material excavated for the subways could, as far as available, be used to fill in the parkway to give a good general slope from the central part outward, to fill in the approaches to the cross street bridges, and to give the park space a more or less irregular contour to avoid monotony of appearance.

There are also indicated on the map numerous crosstown parkways, also parkways connecting together Morningside, St. Nicholas and other parks in the upper part of Manhattan, and extensions to the Riverside Park system. Three additional parks of considerable size are indicated just below Forty-first, Twenty-first and Rivington streets, respectively, to supply the need of that part of the city which is now deficient in park accommodations. A good-sized park is also indicated at the Harlem, north of Central Park.

At each crosstown parkway (every mile) there should be turnouts connecting the north and south auto tracks with the crosstown tracks, and also with the regular streets. The auto tracks would, therefore, only be used for through travel of one mile or more, and would be left at the crosstown parkway nearest to the auto's destination and the ordinary streets followed for the balance of the distance.

The three proposed new parks in the lower part of the city would probably only be possible of consideration in connection with the abandonment of a large part of Central Park. If there are no legal bars against this being done, what sufficient reasons, outside of purely sentimental ones, are there for not cutting Central Park into good sized sections and distributing them about the city in places where they will be of the greatest benefit to the most people? A park one-fourth to one-third the size of Central Park is larger than the average citizen would care to stroll over, and with the driveways and auto tracks provided by the universal park and parkway system, those who frequent the park on wheels would seem to have no good reason to complain, and good driving would be within convenient reach of all parts of the city.

If parts of Central Park were to be abandoned, it would be best done by maintaining the present outer lines by retaining a strip along each side and each end some 500 feet in width for parkways (this would protect the interests of owners of property now fronting on the park) and retaining the middle portion of the park, where the reservoirs are situated, intact, disposing of large rectangular sections of the park at each end. If the reservoirs are to remain the area

taken up by them should be reclaimed for park purposes by covering them completely by means of a system of concrete arches. This reclaimed area would be available for tennis courts and playgrounds, leaving the area now used for those purposes free for other use. The value of ground in the Central Park section is sufficient to warrant reclaiming the reservoir area.

If the abandonment of the reservoirs is contemplated, it would be preferable to divert the central part of the park to public building or residence use and retain a large section at each end for permanent park purposes rather than to follow the plan described in the preceding paragraph.

While it may possibly be too late to carry out the herein proposed scheme in full in Manhattan, the same is not the case with respect to Staten Island, parts of Long Island and parts of the Bronx. The building areas on Staten Island are so small that they would offer but little obstruction to the course of parkways and suitable parks. The Bronx is already fairly well provided with parks and parkways, and the requisite additions could easily be made.

Appalling as the expense of the proposed parks and parkways may appear on first thought, a little consideration reveals the fact that the increase in the value of property along the parkways would be immense, and if the city could condemn a strip of ground extending some 100 feet wide on each side of each parkway, these strips could be disposed of at such an advance that the expense of the parkways would be more than paid. The result would be a much more healthy, beautiful and efficient city at a financial profit.

The scheme is one which might well attract the attention of one or more multi-millionaires who are looking for an opportunity to leave a suitable monument, or who desire to invest wealth for the benefit of present and future generations. The benefits to humanity might be expected to exceed anything likely to result from any of the proposed "Foundations," both in extent and duration.

GEARING FOR MACHINE TOOLS

AN ANALYSIS OF THE ALL-GEAR DRIVE

By Thomas R. Shaw

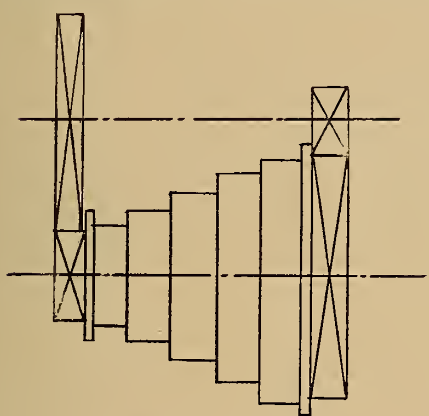
THE all-gear drive for machine tools has come to stay in spite of criticisms to the contrary, and we see evidences of its increasing popularity. It has been suggested that this drive is a change in fashion, and that shortly as fashion changes again we shall revert back to the cone pulley drive. But if this reaction is to take place, then electric driving will also become obsolete, because it is unquestionably due to the more extended use of electric driving in engineering workshops that the all-gear drive has become a necessity. Then the use of high-speed tool steel added a further impetus to its invention. When the cutting tools were perfected to such an extent that they could stand high-speeds, and the heat generated by these speeds, the old-style cone drives were found lacking in power. The cutting of metal at high rates of speed had called for a new design, increasing the power anywhere from two to ten times, hence the need for the gear drive and the single belt. This did not by any means eliminate the cone pulley, because of the fact that there is a great deal of work of a light character where the cone pulley could be used to most advantage.

Every type of machine tool seems to go through a process of evolution and just now it is the question of the all-gear drive that occupies the attention of most makers and prospective buyers. There is a subtle fascination attached to these drives which attracts all who have to take any share in them from the designer to the salesman, for to the latter they undoubtedly make good "talking points." Especially does this apply when it can be pointed out that the changing of speeds is the essence of simplicity; that there is no chance of putting two speeds in at one and the same time, thereby causing a smash-up; that only a small number of handles are requisite to obtain all the changes; that a minimum number of wheels are required to obtain a maximum number of changes; that a minimum number of wheels are running idle; that the whole is neatly encased, and that the whole is what is commonly termed "fool proof."

These certainly are all good points on which to argue and impress the buyer, but it is that feature of constant power transmitted which is of vital importance and makes the all-gear drive stand out pre-eminently above the old cone drive. And what is the old cone drive? Usually a 5-speed cone with a narrow belt. The cone drive was made originally to give a variety of speeds, therefore a long length of cone pulley was required. Necessarily, the width of belt was cut down, because to make a cone pulley with a belt of sufficient width to give great power would not only make it difficult to shift the belt from one step to another, but would increase the length of the headstock to undue proportions. This always limited the amount of power that could be obtained through the belt. Because of the small diameter of the bottom step of the cone, there was much slipping of the belt on the first and fifth steps. Often the range of spindle speeds was not graded and there would be overlapping of speeds. There would be a big gap between the speeds when with open belt and with back gear. The first back gear

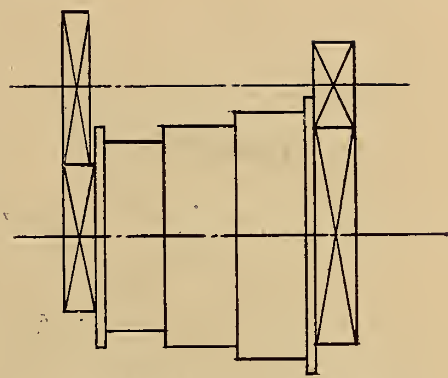
speed would be too slow and the last open belt speed too fast, and the work consequently done on the slow speed, and this before the days of high speed steel was always tolerated.

Of all machine tools none, perhaps, at the advent of high-speed steel, was so ill-adapted to meet the demands to be made upon it as the lathe, because of the fundamental weakness of the cone pulley, which has the belt running at its slowest speed and delivering least power when most power is required. The difficulties to be met are at their maximum in lathe drives because of the wide range of speeds required. The problem has



OLD-STYLE PULLEY DRIVE

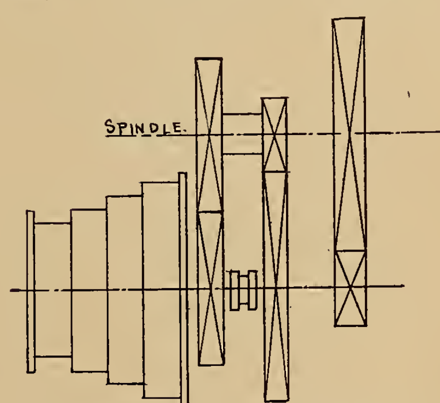
been attacked in many ways. One line of development has been in the increase of the widths of belts with the reduction of the number of steps of the cone and the enlargement of the small step of the cone in order to cut down the reduction of belt speed when the belt is shifted on to the large step. This change was also inaugurated with the intention of limiting the range of diameters of work to be done in a single lathe. Later on the speed range was increased by the addition of double back gears, and this construction unquestionably meets many of the requirements. The use of a mechanical belt-shifter simplifies the moving of the belt on the cones. Then followed the single pulley drive, with the belt



WIDE CONE WITH SMALL BACK GEAR RATIO

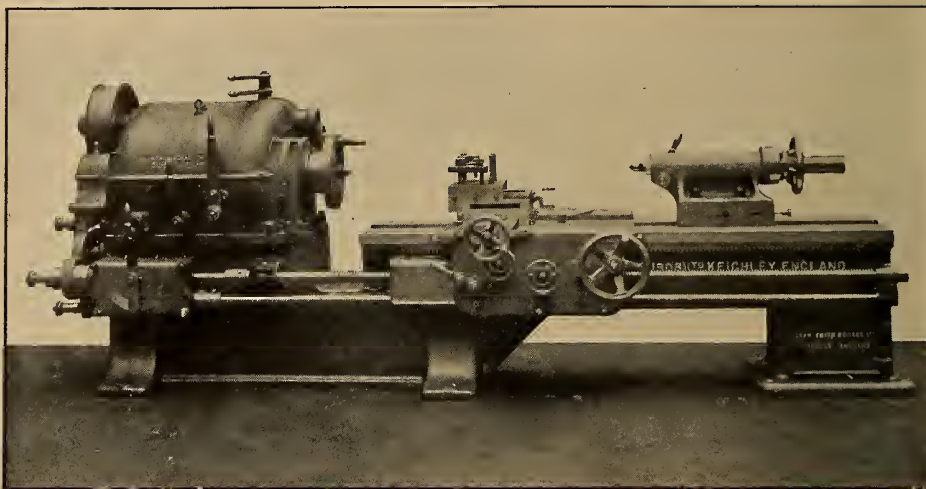
running at a constant speed, the changes to the spindle speed being accomplished by the movements and combinations of gearing.

In looking over the various gear drives that have been produced during the past few years, one is naturally surprised at the variety of the mechanisms employed. As a matter of fact, all the advantages that could be possibly obtained with an all-gear head could be obtained better with a



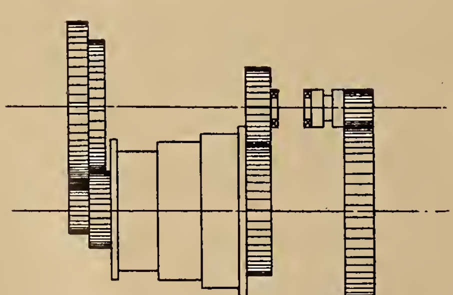
CONE ON SIDE SHAFT. WITH THIS DRIVE THE CONE MAY BE INCREASED IN DIMENSIONS AND ALWAYS RUN AT A HIGH SPEED

variable-speed motor and comparatively few mechanical changes. This was owing to the fact that the electrical changes could be obtained with a much smaller friction loss; that the change increments were much closer; that the speed could always be obtained while the machine was in



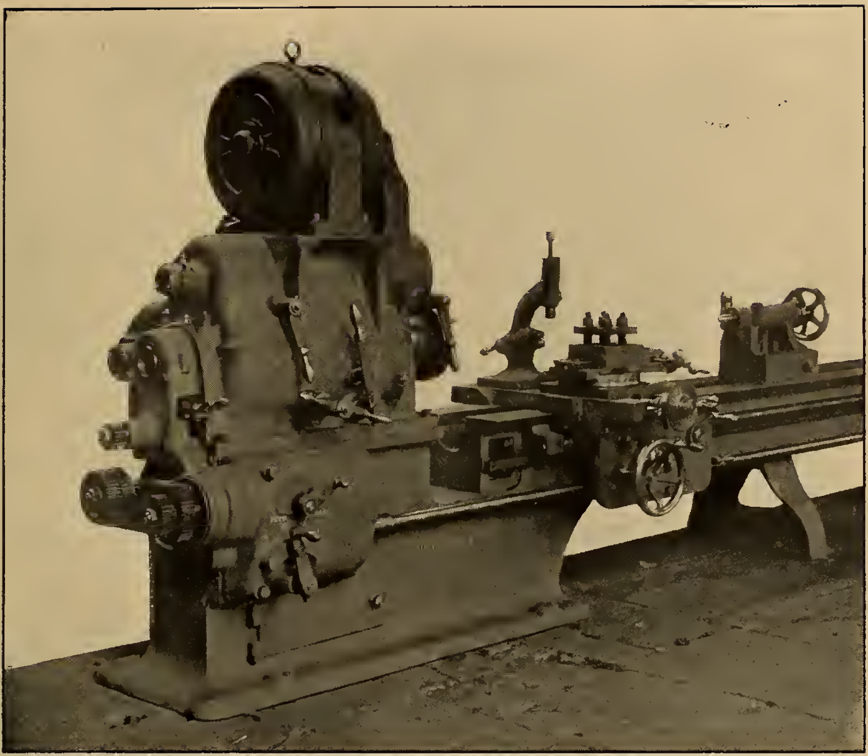
ONE OF THE LATEST ALL-GEAR HEAD LATHES AS MADE BY MESSRS. DEAN, SMITH & GRACE, LTD., KEIGHLEY

motion, not necessarily stopping for changing and doing away with all overhead work. In other words, the variable-speed motor drive was the ideal geared head machine. As these seemed to be so successful, it is difficult to explain the re-action that has set in in favour of constant-speed motors. True, these latter have constant maximum efficiency, whereas variable-speed motors sacrifice some of their average efficiency to their speed range; but where constant-speed motors are used, speed variation must be obtained mechanically, and gears and other transmissions providing variable speeds are sources of some loss in efficiency that may or may not equal the loss in variable-speed motors. Constant-speed motors cost somewhat less than variable-speed motors, but the principal saving in installation expense is in the simpler controlling apparatus for the constant-speed motor.



AN EXCELLENT EXAMPLE OF CONE DRIVE. TWELVE SPEEDS OBTAINABLE

Whatever may be the cause, it is evident that the head with a number of mechanical changes is very popular. If installed as a belt-driven machine, it reduces to a minimum the alterations necessary if at any time the machine is to be converted to motor driving. Since gears must be used anyhow, it is perfectly feasible to gear down from the driving shaft to the spindle for even the fastest spindle speed. In addition to the quickness with which the changes can be made is the obvious advantage that the belt always runs at full speed, consequently at whatever speed the spindle is running, the full power is available at the cutting surface. As only one belt is required, it is practicable to use a much wider belt than is possible with a cone pulley, and the maximum belt effort can be used and more power delivered through a relatively large diameter pulley running at a high speed. This naturally much increases the average output of the machine. As belt shifting is done away with, the life of the belt is prolonged, and the drive is more widely adaptable than when a

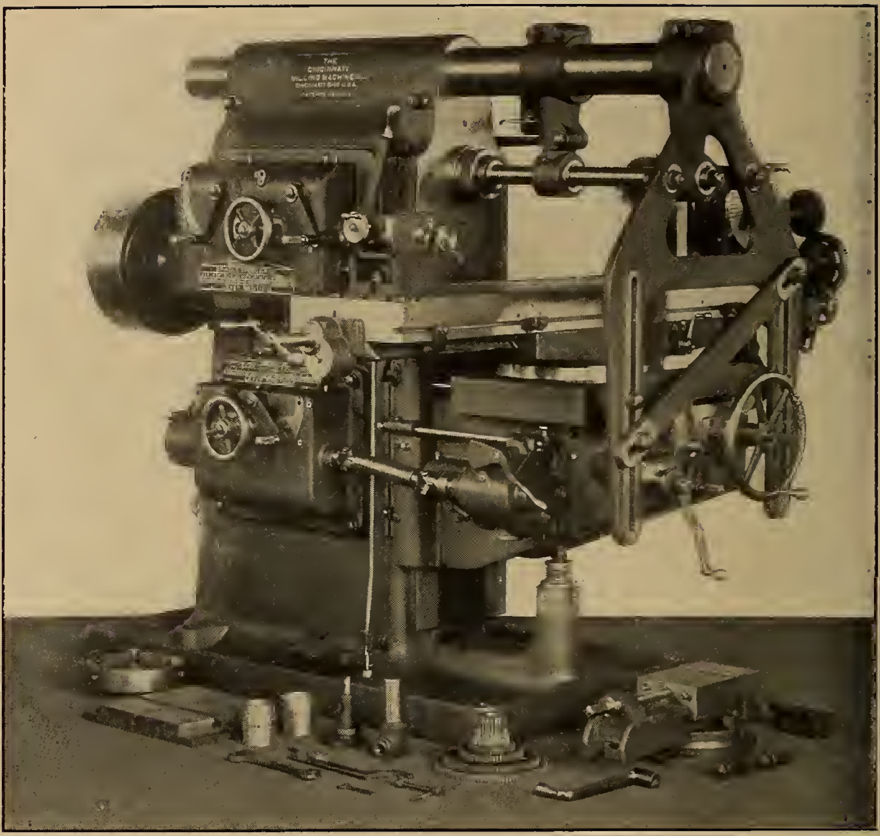


ALL-GEAR HEAD LATHE, 10-INCH CENTRES, DRIVEN BY ALTERNATING-CURRENT MOTOR MOUNTED ON HEADSTOCK. MESSRS. JOHN STIRK & SONS, LTD., HALIFAX

cone pulley is used. Often another advantage is the placing of the driving pulley in a more convenient location than is possible when it is directly mounted on the spindle.

Ease of control unquestionably results in the rapid and economical production of work. Where the work varies considerably in diameter, frequent changes of speed will be required, and where the most efficient cutting speed can be obtained by simply moving a conveniently located handle, the work will be turned out at a maximum speed. If frequent shifting of belts is required, a great deal of the work will be done at less than maximum speed owing to the extra exertion involved. The decision as to correct cutting speeds for a given material and given rates of speed and their relation to one another is no longer a matter of experiment or an individual's opinion, but more nearly an exact science, so that shop managers now know what results should be realized from the tools in use. Given this knowledge, it becomes highly desirable that machine tools be equipped with sufficient range of speeds and with *small increments of variation* to allow very closely approximating the most advantageous speed for the work in hand. Too much emphasis cannot be laid on the question of small increments of variation, which consequently means a low ratio between highest and lowest spindle speeds, and in this the designees of all-gear heads appear to be unanimous.

It is very evident that the number of speeds usually obtained with a cone pulley drive, viz., ten, and sometimes twelve, is not enough for economy. There should never be less than sixteen, for there is always that intermediate diameter to be turned at



UNIVERSAL MILLING MACHINE WITH ALL-GEAR DRIVE AND ALL-GEAR FEED. CINCINNATI MILLING MACHINE COMPANY, CINCINNATI

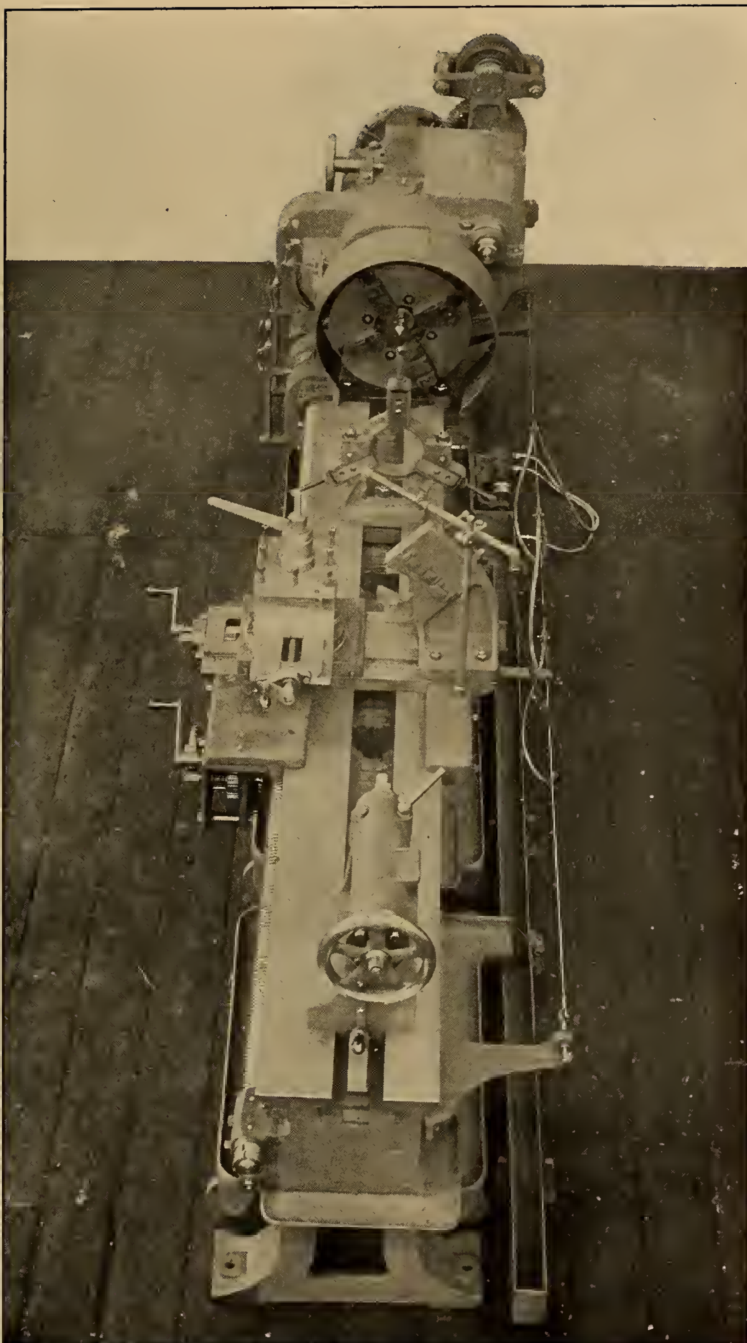
Note that similar arrangements are used both for drive and feed. Each of the mechanisms is made as an independent unit.

the wrong speed, and therefore at the greatest cost, so that the more changes of speeds we have the better is our ability to work profitably.

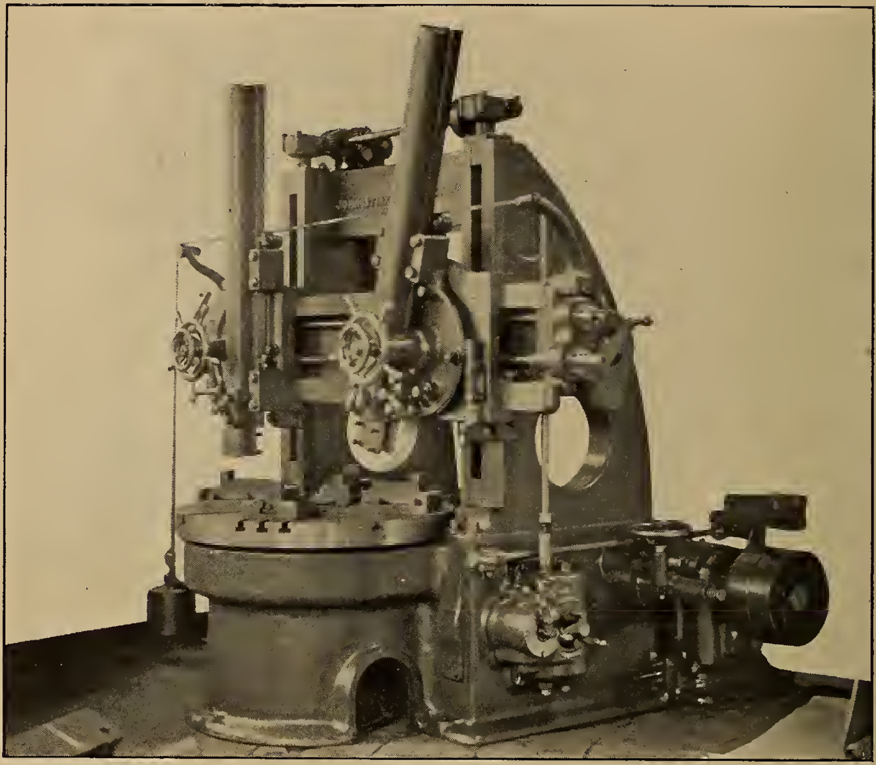
A very simple illustration can be used to show the loss due to incorrect speed. Say we have a shaft of any diameter and material is such that 50 ft. per minute is the correct cutting speed. The nearest speeds obtainable in the lathe in which the shaft is to be turned give 40 ft. and 60 ft. The latter being too high, the work has to be done at 40 ft., in which case we have only 40-50 of the speed we should have 4-5, or a loss in time of machining of 20 per cent.

According to Mr. F. W. Taylor an increase of only 1 ft. per minute above the *correct* cutting speed is sufficient to make a high-speed steel tool a success or a failure. Thus we see the value of small increments of speed.

In all cases where machine tools are motor driven, it is desirable to mount the motor on some part of the machine if possible rather than on the floor near the machine. Here the all-gear head shows to advantage, because in many of the designs the cover is so arranged as to receive a motor at any time. A machine tool so driven becomes an independent, self-contained unit, which can be moved as a whole and located wherever desired. One of the mechanical



PLAN OF LATHE WITH ALL-GEAR HEAD ARRANGED TO TAKE EITHER PULLEYS OR ELECTRIC MOTOR. MESSRS. THOS. RYDER & SONS, BOLTON



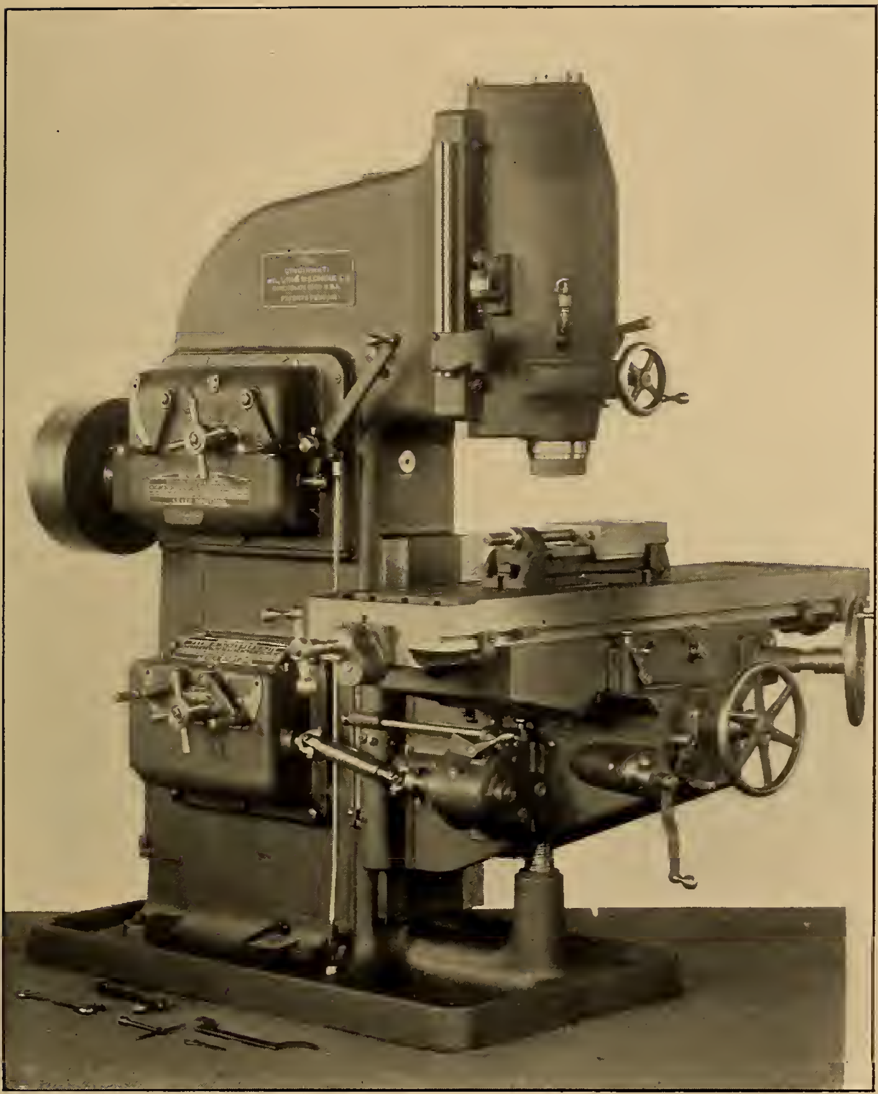
FOUR-FOOT BORING AND TURNING MILL WITH GEAR-BOX DRIVE. MESSRS. JOHN STIRK & SONS, LTD., HALIFAX

The gear box is an independent unit and may be driven by pulleys, as shown, or by an electric motor.

difficulties encountered in attaching individual motors to small machines was the unwieldy size of some of the earlier motors of small capacity. Sometimes the motor would be as large or larger than the machine, and this feature was largely responsible for the prevalence of group driving of small machines, even where the individual drive would have been preferred. Recent improvements in motor design have led to a great reduction in the size of motors for a given capacity, so that the 20 horse-power motor of to-day is not nearly so large as the 10 horse-power motor of earlier years. It is, therefore, much easier now to make the motor an integral part of the machine.

Although it is so convenient to mount a motor above the all-gear headstock of a lathe, yet the best location for a motor on a lathe and on most machine tools, is as low down on the machine as possible. The amplitude of the vibrations set up will be smaller the closer the motor is to the floor, and the liability of chattering will therefore be reduced. The location of the motor in the cabinet leg or in the headstock of a lathe is ideal, but there are, of course, many cases where the motor must be mounted over the headstock because no other place is available. The necessity of having the motor out of the way of the work is obvious, as dirt and cuttings, if allowed to get into the motor, would at once give rise to electrical troubles, especially in direct current machines. So that on the whole, mounting the motor above the head seems to be the best way, and a clear floor space is then left for sweeping.

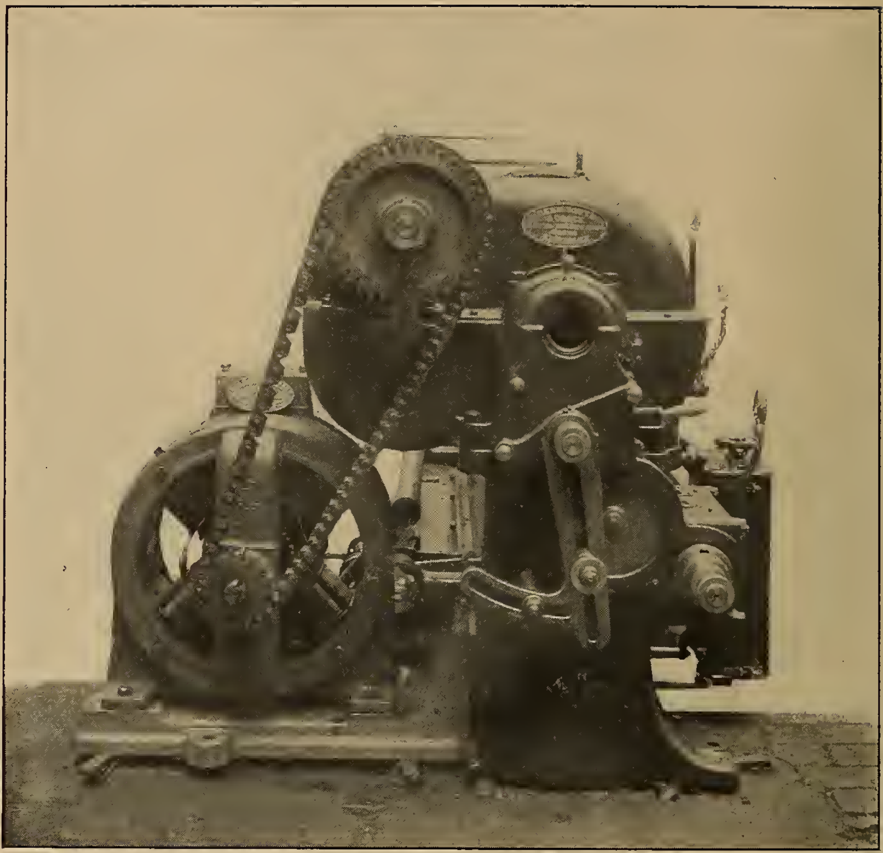
All-gear heads may be divided into



VERTICAL MILLING MACHINE, SHOWING THE APPLICATION OF THE GEAR-BOX UNIT SYSTEM.
CINCINNATI MILLING MACHINE COMPANY, CINCINNATI

four general types; those with sliding keys, sliding gears, clutched gears, or some combination. The sliding key type has certain advantages; it is economical in space, and the speed may be quickly changed while the machine is in motion. But it is liable to get out of order, and all-gears in the train revolve, some of them idly, it is true, but it is the idle wheel, not the loaded one, that makes the most noise, and while this type may be used very appropriately for a feed motion, it is not suitable for a main drive.

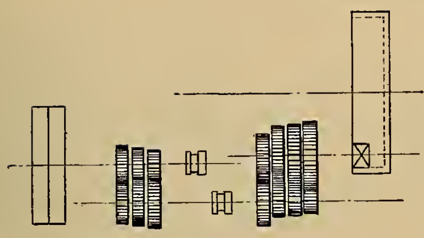
There are many examples in use of friction clutches of both positive and friction types. In turret lathes the latter type is a necessity, because it is necessary to instantly obtain fast and slow rates of spindle speed, according as different tools are pre-



END VIEW OF LATHE, SHOWING APPLICATION OF ELECTRIC DRIVING, WITH CHAIN GEAR. MESSRS. DEAN, SMITH & GRACE, LTD., KEIGHLEY

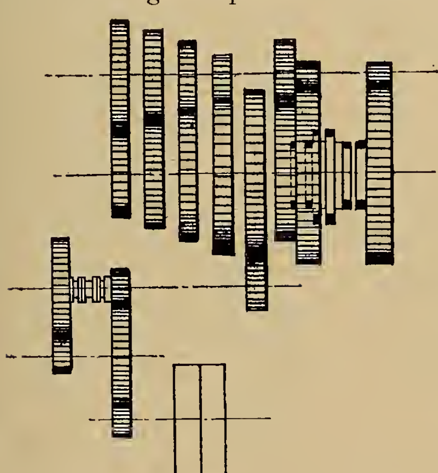
sented to the work. For reliability, simplicity and number of changes obtainable, however, there is nothing to equal the sliding-gear type—either with plain sliding gears or with tumbler cone gearing of the Hendey-Norton type.

The combination type is endless in its variety. One of the latest features is the use of the "silent pawl" or free wheel, which has much to commend it, and has found favor with several makers. The ratchet wheel is attached to the slowest running gear of any particular cone of gears, and so long as the driving shaft is running, and the other gears in the cone are disengaged, the pawl and ratchet wheel rotate together with the driving shaft, but when any one of the faster speeds of the cone is in use, the ratchet wheel, which is keyed to the driven shaft, simply runs ahead of the slower rotating gear carrying the pawl. The pawl is generally provided with a small projecting piece, acting as a bell-crank lever. A spring carried on the ratchet wheel, and clipping it so that it can slip when necessary, abuts against this bell-crank lever, and when the ratchet wheel rotates faster than the pawl the spring forces the pawl out of engagement and there is no objectional clicking. When the speed of the ratchet wheel drops below that of the pawl the spring again comes into play and forces the pawl into contact with the ratchet teeth.



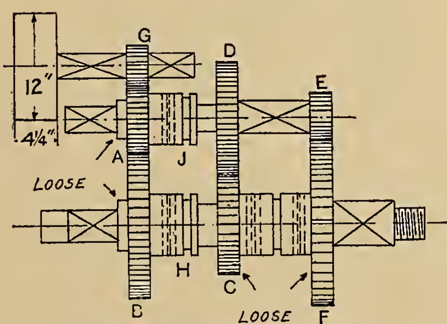
A.—SLIDING KEY HEADSTOCK GEARING

In diagram *A* is shown the developed plan of a headstock gearing, in which sliding keys are used. It will be observed that there are two sets of gears; three speeds being given to the second motion shaft, and then these multiplied by four give twelve changes to the spindle. A feature to be noted is the driving of the faceplate direct from the last motion shaft. In diagram *B* we have a combination of a sliding key with clutches, and in which we see the effect of combination, for, whereas in case *A*, 16 gears are required to give 12 speeds; in case *B*, 21 gears give 24 changes, and as we consider further examples, the effects and possibilities of combinations will show even better results. Here a claw clutch is used to give the first two changes. This motion is then transmitted through a pair of gears to a sleeve running loosely on the spindle, this sleeve taking the place of the cone



B.—COMBINATION OF SLIDING KEY AND CLUTCHES

pulley in an old-style drive. On this sleeve are keyed four gears, meshing with corresponding gears on a back shaft; these latter run freely on the shaft, but each may be connected and drive the shaft through the means of a spring key. Thus the back shaft has eight changes of speed. Thence the spindle is driven through any one of the three pairs of gears at the right hand, each gear on the spindle being provided with a claw clutch, to engage with a sliding clutch, keyed to the spindle.



Gear Runs.	Ratio of Gearing.
G A D C	1·42 to 1
G A B	3·7 to 1
G A E F	9·8 to 1
G A B C D E F	25·5 to 1

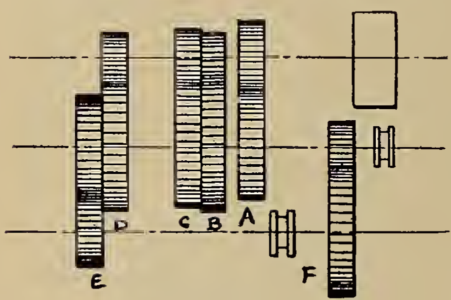
C.—CLUTCH SYSTEM

Thus twenty-four changes are given to the spindle, and all speeds pass through one of the last three pairs of gears. It will be observed that a very high speed is required by the driving pulleys, thereby giving an efficient belt speed, and that the position of the pulleys could be occupied by a motor which could run at the same speed.

In case *C* we have a clutch arrangement, with only a small number of changes. The pinion *G* is constantly running, gears *A*, *B*, *C* and *F* all run freely, and gears *D* and *E* are keyed to the shaft. The clutches are all keyed, clutch *H* being keyed to an extension of the hub of gear *C*. Gears *C*, *D*, *E* and *F* form a double-gear combination. Four changes are given.

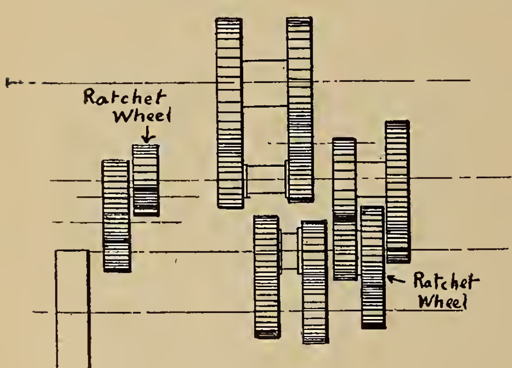
Friction clutches are used in case *D*, an independent clutch being used

in each of the gears, *A, B, C, D, E,* and *F.* Two operating levers are used to engage the clutches. A headstock of this type is the only one in which changes can be made instantaneously, but friction clutches are often vetoed on account of the trou-



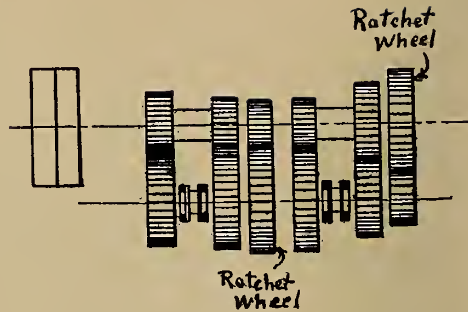
D.—FRICTION-CLUTCH SYSTEM

ble occasioned by slipping. An expanding ring clutch, which automatically tightens itself, is used in one of these heads. The lever, which spreads open the ring to grip the revolving part, is operated by a cam, which is moved endwise under it, and so formed that the lever is cause to ride further up the cam in the event



E.—PAWL AND RATCHET SYSTEM

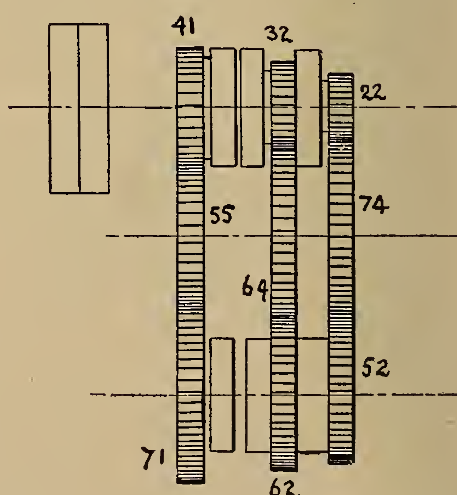
of any slip taking place. In another case of a well-known turret-lathe, a combined friction and positive clutch is used, the friction taking hold first and starting the changing without shock, and then the positive clutch coming into action immediately afterwards. Some such devices are



F.—PAWL AND RATCHET SYSTEM

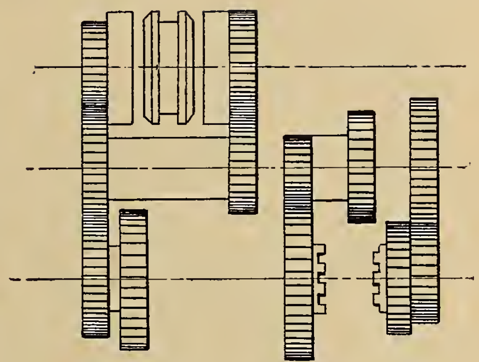
necessary to make a friction geared lead satisfactory.

In cases *E F* and *G* we have examples of the use of the silent pawl and ratchet wheel. The first of these looks rather formidable, when we see there are twenty gears in mesh, and all these are running. Only nine speeds are given to the spindle through the double-wheel keyed thereon, but these are in either direction, so there is an equivalent of eighteen speeds. Actually only twelve gears are required to give the changes, the other gears in the train being used for reduction of speed and reverse. The same gear reduced to simpler elements is in case *F.* These are arranged in a box, and only two centers are used. The first



G.—RATCHET AND CLUTCH SYSTEM

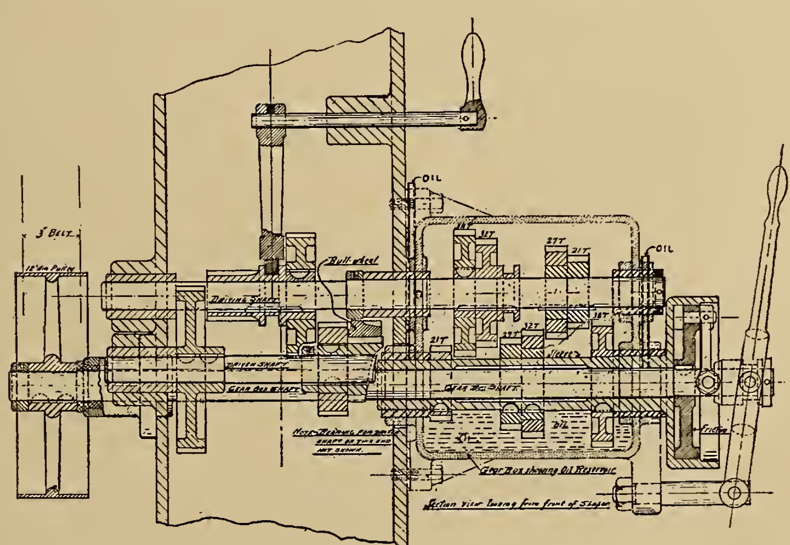
H.—CLUTCH AND RATCHET SYSTEM



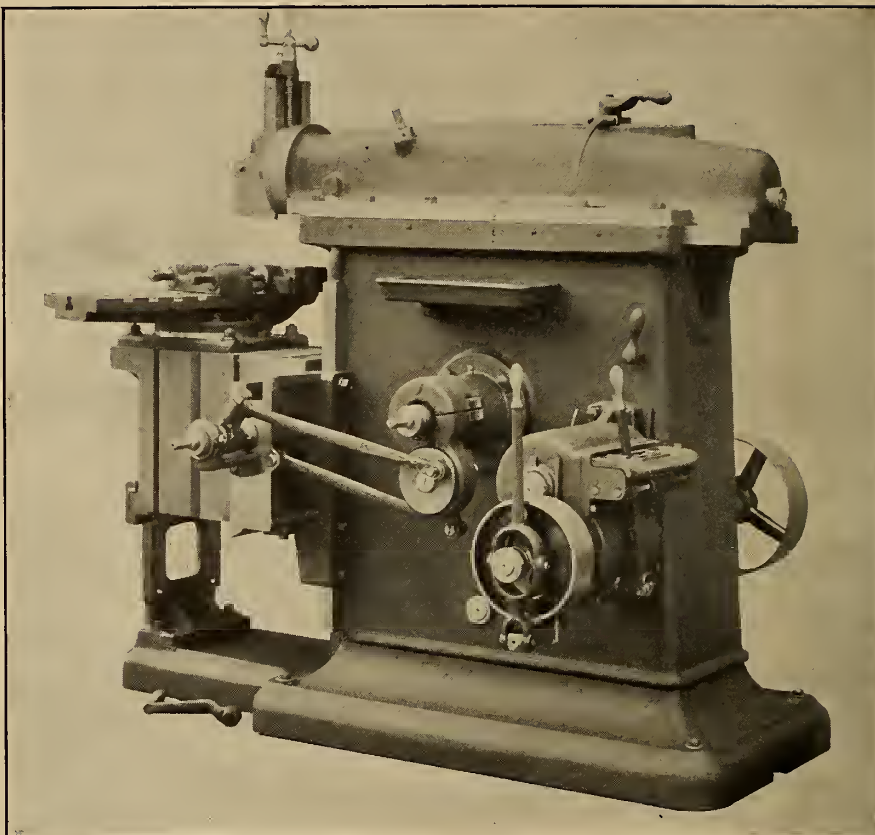
J.—CLUTCH AND RATCHET SYSTEM

nest of three gears is keyed to a socket and drives a corresponding nest of gears running loosely on a shaft. A clutch connects either of the two quicker running gears, and a ratchet wheel the slow motion. A similar set of gears is on the right-hand side and transmits the motion through a shaft in line with the pulley shaft. Nine changes are given and only two operating handles are necessary. Twelve gears are required, but case *G* shows a unique arrangement, whereby the nine changes of speed can be obtained by the use of nine gears and the same number of clutches and silent ratchet wheels. Cases *H* and *J* show how, with twelve gears at their disposal, different designers get eight and twelve speeds respectively.

We now leave the clutch examples and turn our attention to those in which the changes are made by sliding gears. Shapers, among other tools, have also come to be driven by the all-gear drive, and a good example is given in the photograph on page 420, while a section through the body of the machine and gear box is given in case *K*. In the gear box itself there are four changes, eight gears being required, and in the body there are two more sets of



K.—GEARING OF QUEEN CITY SHAPING MACHINE



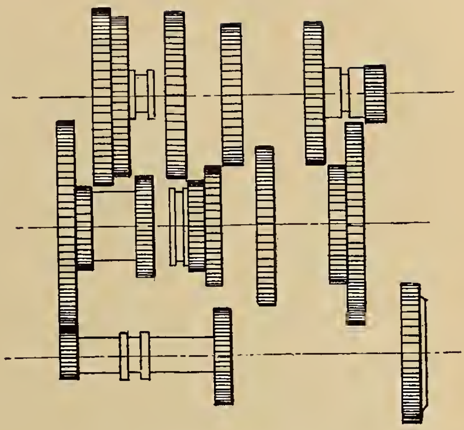
PILLAR SHAPING MACHINE WITH ALL-GEAR DRIVE. QUEEN CITY SHAPER COMPANY, CINCINNATI

gears, giving altogether eight changes of speed. It will be seen that every pair of gears has an out-of-gear position, and only the gears actually required are in mesh. This is a most valuable feature, and is one in which the sliding-gear system predominates. All the previous examples, with clutches and sliding keys, have all the gears in mesh continually, and in such cases power is being wastefully consumed, and useless wear of the gearing is taking place, which, except in very few cases, is poorly compensated for by the quickness in making changes.

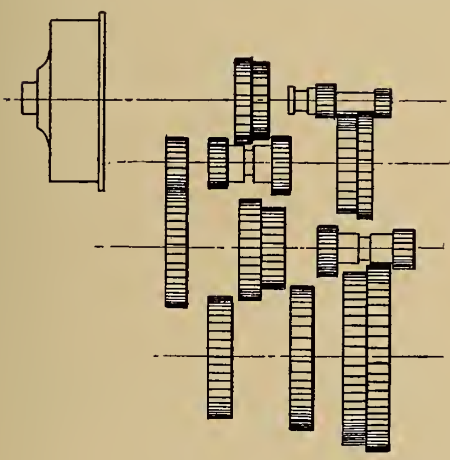
Of two machine tools the one that requires the least amount of power to drive its own mechanism in doing certain work is the better for at least two reasons, the cost of power in the machine is less and the wear is less. It has the advantage both going and coming. In looking over machine tools purposing to buy, it is sometimes advisable to consider their relative merits as *consumers of power*, and then figure out what that consumption really means. The day will come when such analysis will be common. Such analysis will tend to establish efficiency ratings for machine tools. And why shouldn't a machine tool have an efficiency rating as much as a boiler, or engine, or dynamo?

Cases *L* and *M* each give diagrams of sliding-gear combinations to give sixteen speeds, and in each case there are only three pairs of gears in mesh at any one time. Case *N* is a very interesting combination, with thirteen wheels eighteen changes are obtained. It is also unusual, because the double gear occurs at the first motion. The

first motion pinion is attached to the pulley and runs loose on the shaft. It is provided with a clutch, through which the motion of the pulley may be transmitted to the shaft direct, the gear with the corresponding clutch being moved to engage it; or the drive may be transmitted through the double gear to the shaft. Then, on the driving shaft and on the spindle there are two sliding cones of gears, three in each, which may be brought to mesh with three fixed wheels on the intermediate shaft. Comparison of this last set with case *G* shows a similar arrangement of gears, but, in the case under discussion, the changes



M.—SLIDING-GEAR COMBINATION

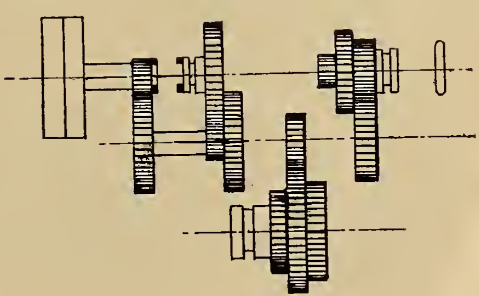


L.—SLIDING-GEAR COMBINATION

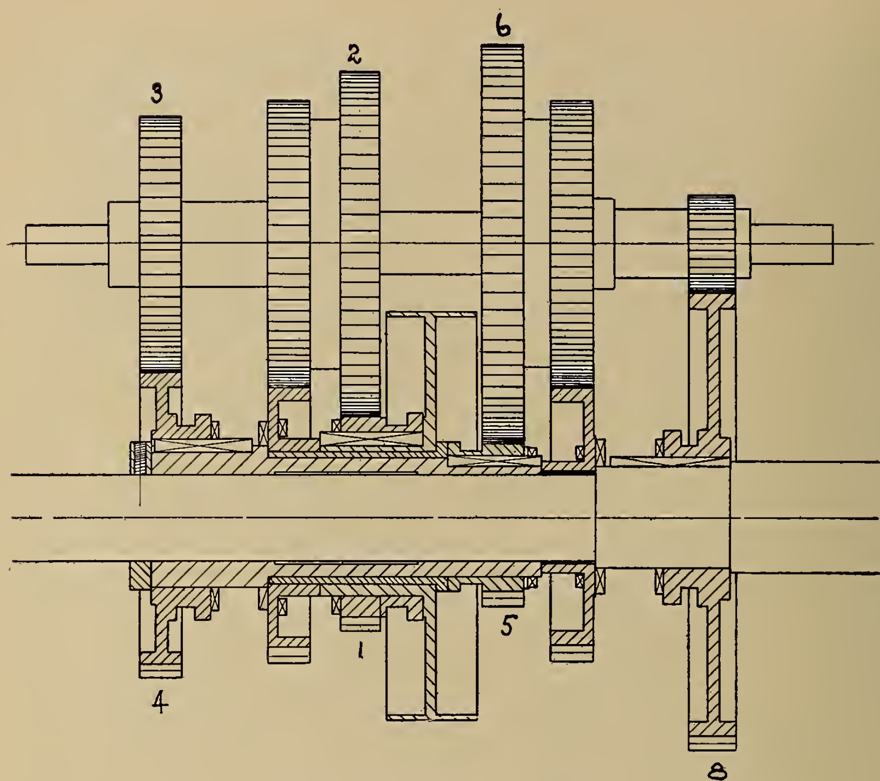
are made by sliding the gears instead of with clutches.

An ingenious combination of clutches, attached to sliding gears, is given in case *O*. Two shafts carry the gearing. On the main spindle are six gears, with the belt pulley in an unusual place, *viz.*, in the center. The front gear slides on a key sunk in the spindle. That immediately behind has a fixed position longitudinally, but runs free on the spindle when not clutched to the adjacent sliding gears. The remainder of the spindle is surrounded by a sleeve, on which are mounted, first, a sliding gear, then the driving pulley with a long boss, on which is keyed a sliding pinion. Next, another free gear, and then a sliding gear keyed on the end of the sleeve. Also, on the right-hand end of the sleeve there is a sliding pinion. The two free gears have clutch teeth on both sides. The back gears form part of two sleeves running on a fixed shaft, with a distance piece between them opposite the main pulley. The various gear combinations made by sliding and clutching are effected by four levers. There is an out-of-gear position for each gear, so that two combinations cannot be in together. As shown in the diagram, the motion is transmitted through the gears 1, 2, 3, 4, 5, 6, 7 and 8.

For simplicity of arrangement there is very little to equal the tumbler gear principle, with which, in combination with sliding gears, it is possible to obtain the greatest number of speed changes with the lowest num-

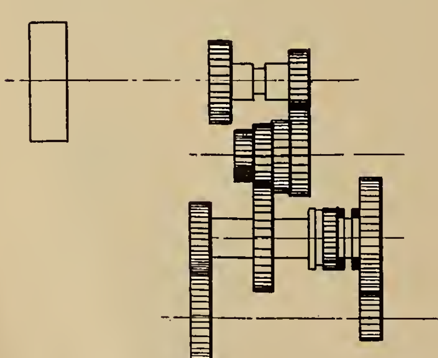


N.—SLIDING-GEAR COMBINATION

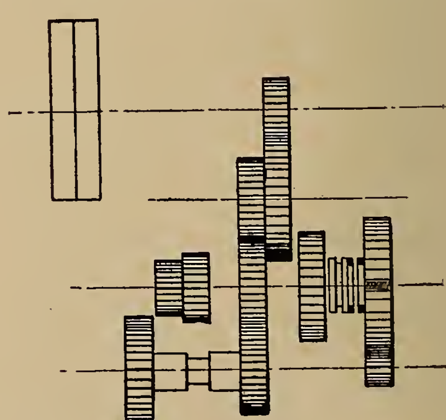


O.—CLUTCH AND SLIDING-GEAR COMBINATION

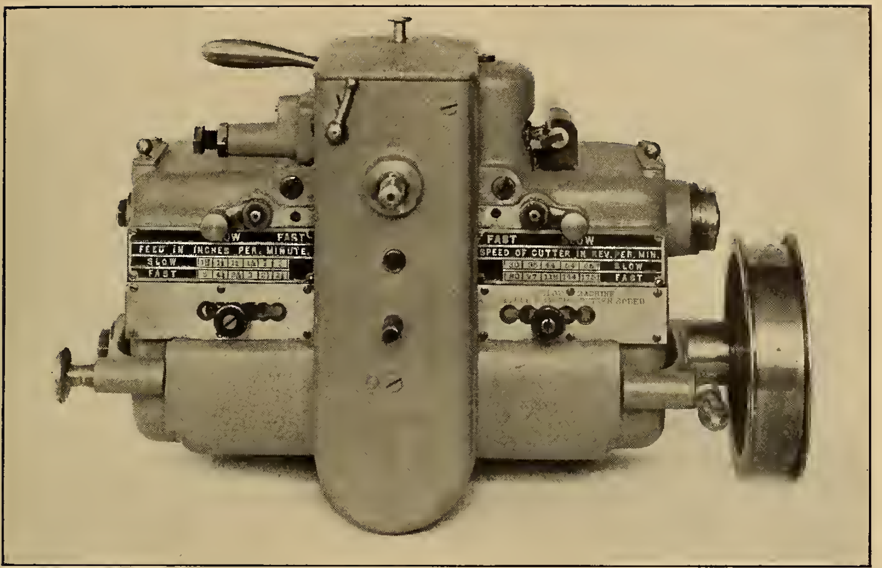
ber of gears. As may be expected, the arrangement of these are as varied as there are designers. In some instances but a single gear is carried in the tumbler frame, while in others, as case *P* and *Q*, the cone of gears is carried in the tumbler frame. In cases *R* and *S* we see how the number of speeds increases very rapidly, in *R* there being twenty speeds with fifteen gears. There are five gears in the cone, and it will be easily seen that by the addition of one more gear in the cone there would be twenty-four speeds. Seventeen gears give twenty-four speeds in case *S*,



P.—TUMBLER GEAR SYSTEM



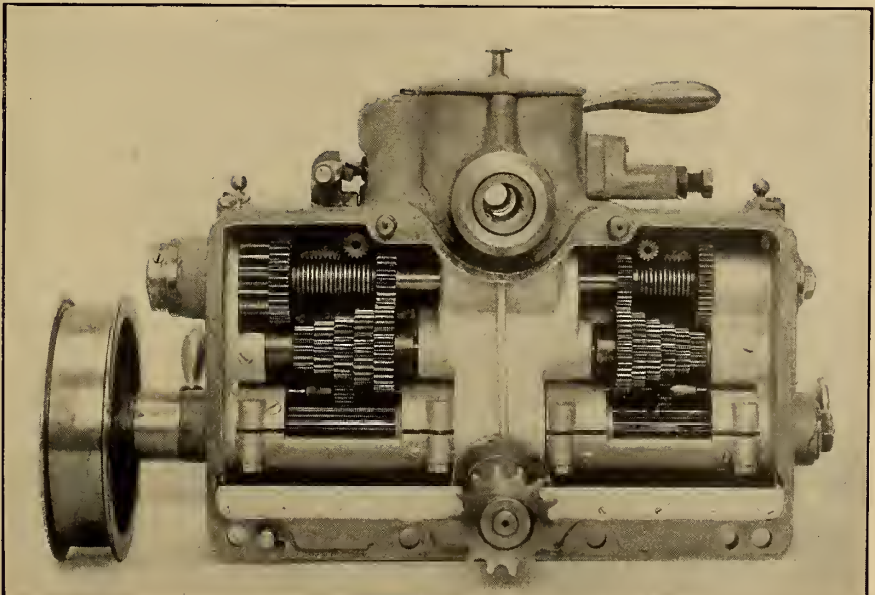
Q.—TUMBLER GEAR SYSTEM



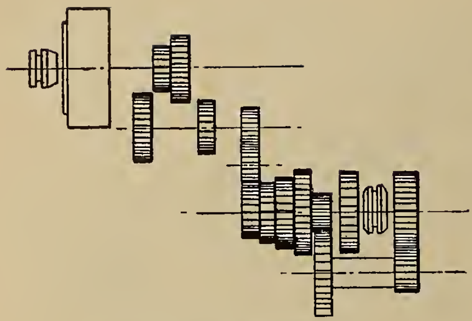
AN EXCEEDINGLY NEAT GEAR-BOX ARRANGEMENT, WITH TUMBLER GEARS. ONE SIDE DRIVES THE SPINDLE OF THE MACHINE AND THE OTHER SIDE THE FEED. BROWN & SHARPE MFG. CO., PROVIDENCE

and this should be compared with case *B,* where the same number of changes are obtained, but with a marked difference in the number of gears in mesh at one time.

An exceedingly neat arrangement of gear box is used on one of the Brown & Sharpe machines, and illustrated by the photograph on page 423. It is of the tumbler cone gear



INSIDE VIEW OF BROWN & SHARPE GEAR CASE

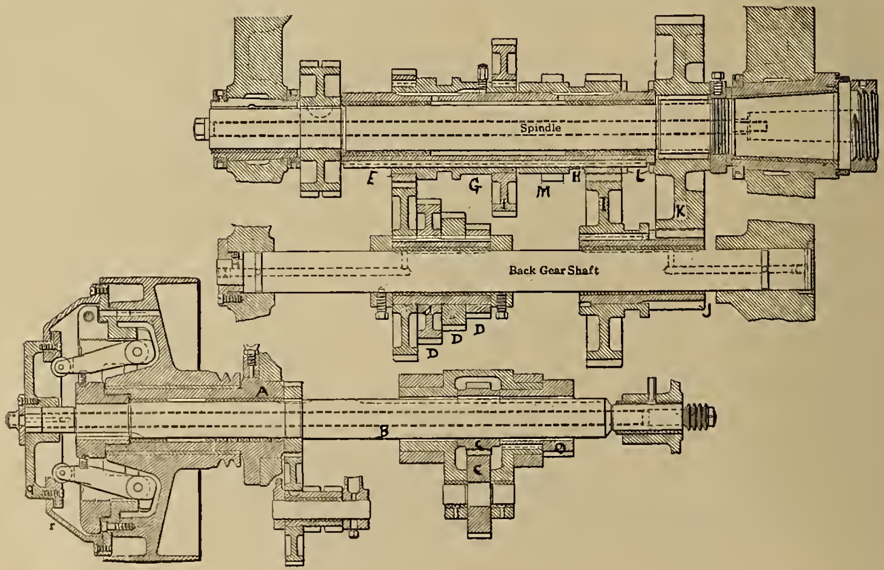


R.—TUMBLER GEAR SYSTEM

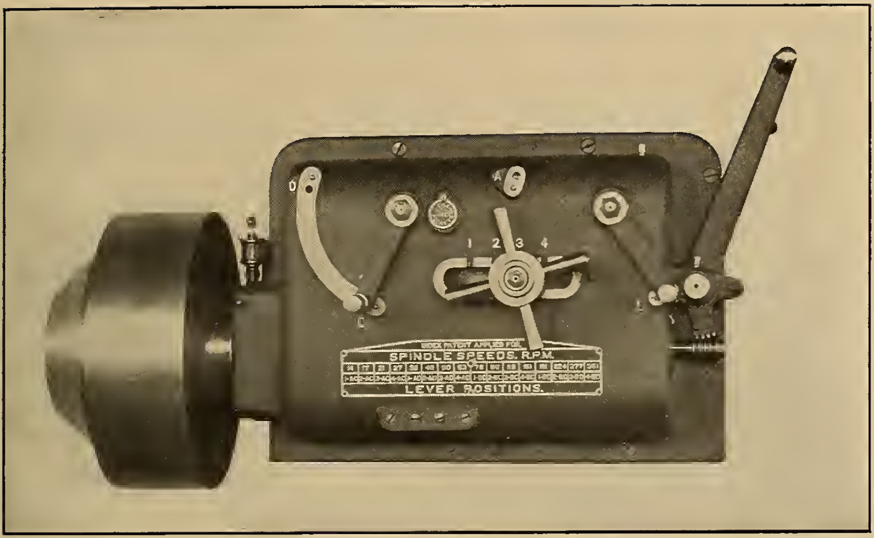
S.—CONE GEAR SYSTEM

type, and contains two distinct sets of gears—one for the speeds and one for the feeds. Both motions are driven from one constant speed pulley at the end, and the speed of either set can be changed without affecting the other. The driving pinion is of sufficient length to cover the cone of gears, and the sliding tumbler pinion always remains in mesh with it. To lift the tumbler bracket into position a handle is placed on the outside, one being at each end of the driving shaft. The tumbler pinion is carried on a shaft, along which it is slided by means of a knob at the front. There is also a train of "back gears," by means of which the number of speeds is doubled. These are attached to a sleeve on the upper shaft. This sleeve has annular grooves turned in it which form a circular rack, and a pinion engages with this, provided with a handle at the front, so that by giving a half-turn to this either of the gears on the sleeve may be brought into mesh with the cone. Ten speeds are given.

The Cincinnati Milling Machine

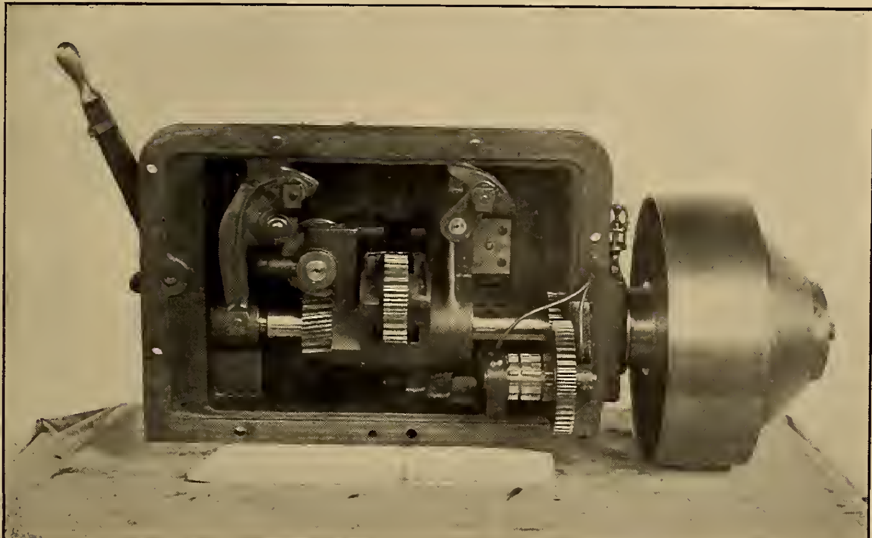


T.—THE CINCINNATI MILLING MACHINE GEAR DRIVE



OUTSIDE OF GEAR CASE OF CINCINNATI MILLING MACHINE, SHOWING OPERATING LEVERS AND SPEED CHART

Company's all-gear drive is a well thought-out mechanism of the tumbler gear type, and is illustrated by example *T* and several photographs, which give a very good idea of the mechanism. The driving pulley is mounted on the bracket *A* attached to the frame, and relieves the driving shaft of all bending strains due to the belt pull. A friction clutch is carried by the pulley and transmits the motion to the driving shaft *B*. This friction clutch is of special construction and serves in a dual ca-



INTERIOR OF GEAR CASE OF CINCINNATI MILLING MACHINE, SHOWING OPERATING LEVERS AND TUMBLER FRAME

Note the worm for moving and locking the tumbler frame

pacity. One-half, operated by the toggle levers, effects the main drive—the other half, consisting of the two outer surfaces, *Q* and *R*, form an auxiliary drive, which is imparted from the pulley to the shaft by moving the actuating rod running through the center of the shaft to bring the faces of *Q* and *R* into frictional engagement. The actuating mechanism is so arranged that this auxiliary drive may be operated by the foot, the lever for which is seen in the general view, and the drive depends on the pressure exerted. This leaves the operator with both hands free to move the various handles to effect the combinations of gearing, and allows the gearing to be slowly turned around until the teeth of mating wheels come opposite.

Power is transmitted through the tumbler gears *C C*, which may be brought into mesh with any one of the cone gears *D*, thence through the sliding gear *E*, the long sleeve *G*, and the backgears *H I J K*. This provides for four different speeds, and if the sliding gear *F* is brought into mesh with one of the cone gears, a different series of four speeds is obtained. Again, if the back-gears are slid out of engagement, and the clutch teeth *L* are engaged, transmission is direct through any one of the four cone gears or the sliding gears, thus giving two additional series of four speeds each, making a total of sixteen different spindle speeds, the eight fastest of which are obtained with only two pairs of gears in mesh. The eight slowest requiring four pairs of gears in mesh. The gear marked *M* is practically an elongation of gear *H*, and is used to facilitate engaging the gears. Assuming that the clutch is in engagement, and the operator wishes to use the back-gears, the movement of the operating lever first disengages the clutch, and then, as pinion *J* is not yet in mesh with gear *K*, it would not revolve. The clutch being out of engagement, gear *K* is also idle, and it might therefore happen that the teeth of *J* would not come opposite the spaces in gear *K*, in which case it would be impossible to bring these two gears into engagement, but the use of gear *M* prevents such a possibility. It enters into engagement with *I* before the clutch is entirely disengaged, and thus *I* and *J* are kept constantly in rotation.

The tumbler frame *M*, which carries the gears *C C*, is positively locked in position in a very ingenious manner. It is trunnioned on the driving shaft and at one end is provided with a worm wheel segment *O*, which meshes with a worm on the end of the pilot wheel shaft. Turning the pilot wheel to the left causes the tumbler frame to revolve and the gears lifted clear of the cone gears. The entire tumbler mechanism may then be moved laterally to the desired position, where it is properly located by a detent pin. Then, by turning the pilot wheel to the right, the tumbler gears are brought into mesh with the proper cone gear, the depth of their meshing being determined by a stop pin, against which a lug on the tumbler frame abuts. Additional pressure on the pilot wheel then serves to act through the worm, forming a combination of screw and levers which locks the tumbler in position. The main driving shaft has clearance through the tumbler and is not subjected to any strain, the weight of the tumbler being supported by the slide.

One other feature of all-gear drives not touched upon is the convenience of making many of these as separate units, as the examples in the Brown & Sharpe and Cincinnati machines, or as independent gear boxes, which can be attached to any style of machine, such as the one on the Stirk boring and turning mill. This is a noteworthy practice in modern machine tool design, and has the great advantage that, independent of creating a standard design, itself of sufficient importance, it enables parts to be made in quantities.

THE MECHANISM OF RIVER BEDS

By V. Lokhtine

Several years ago there was presented to the International Technical Bureau at St. Petersburg a paper upon the important subject of the nature and formation of the beds of rivers, considered as a mechanical problem, and taking into account the large forces acting to produce the result from an engineering viewpoint. The importance of this paper is such that a translation of it into English has been deemed advisable, and we believe that Mr. Lokhtine's analysis will be accepted as indicating the lines along which further investigations may well be conducted in this important department of engineering work.—THE EDITOR.

UNTIL recently the study of the behaviour of rivers was limited to some attempts to discover the causes to which the effects were due by the means of mathematical analysis, owing to the lack of sufficient experimental data. Such analysis has been devoted principally to the investigation of the relations between the various elements of the bed of the stream with reference to the cross section.

Notwithstanding the diversity of these investigations and the high degree of perfection of the mathematical portion of such analysis, permitting us to penetrate boldly into the domain of imaginary relations, we have not been able by this method to find the solution of the broad, actual problem of the régime of rivers and the question of the movement of the water, so that the subject of the formation of their beds yet remains an open matter. We are therefore obliged to turn to the method of actual observation, and to endeavor to find out just how the flow of water in a stream really acts.

Although the field of observation of the behaviour of rivers includes many very detailed reports, we seek in vain among these for any general description of the physical properties of a river, explaining the causes of the present condition of its entire bed, considered apart from any limited portion of its course. The same is true as regards the reciprocal action of the bed and the water, as well as the differences which appear in this respect under the influence of various local conditions.

The literature of hydrotechnics includes many researches into particular cases of the action of river currents. These refer to the behaviour of whirlpools to the helicoidal action of the water, etc., to the relation which exist between the depth of the water and the nature of the bed; to the computation of the flow in terms of the slope, and of the elements of the cross section, etc., etc. We seek in vain, however, for a discussion of the general behaviour of a stream, including such problems as: Why has a certain portion of a river a deep and permanent bed while another similar portion is always filled with deposits? Why, again, do certain portions show a continual disposition to pecularities which prove that such features are not accidental but belong inherently to the bed itself? It is evident that elementary explanations of these questions are not sufficient, since it is well known, for example, that sand-bars prevent the destruction of the banks of a stream in many cases, and that a proper protection of the banks often prevents the formation of the bars. The demands of navigation have long required radical modifications in the normal régime of rivers, seeking to obtain a greater depth of water by modifying the natural bed of the stream and by changing the longitudinal profile. If, however, we make

such radical changes in the natural régime of a stream, we should keep clearly in view the elements which have produced the original channel and consider whether the alterations we make may not be followed by disastrous results. Doubtless many others besides ourselves have considered these questions without finding them answered, in spite of the number and diversity of hydraulic experiments.

Having sought in vain, and finding no solution given to the problem, we have attempted to solve it by our own efforts with this end in view, we have made numerous observations in connection with various works under execution and collated with these such material as we have gathered. The theory here presented is the result of these observations. Subsequent observations will indicate the extent to which the ideas here given are justified. Even if these conclusions are not found to agree wholly with all the phenomena involved in the complicated mechanism of a watercourse, our work will not be in vain, since it will introduce some method into the numerous observations made upon the subject. Until now such investigations have been made without any broad plan of scope and constitute an aimless groping for results. The programme for such observations has been made so wide and so general, for fear of losing sight of some special point, that the data which are really necessary have been buried beneath a mass of useless material, from which they can often be extracted only after immense labour and exertion.

Every river considered, not in any limited portion of its course, but as a whole, is the resultant of three factors which are absolutely independent of each other:

1. Its volume of flow, which is a result of the conditions of the climate and the soil of the region through which it passes, and of the manner in which the rain falls upon the basin containing its affluents.

2. The slope, which depends upon the elevation of the region traversed by the river, and

3. The greater or lesser degree of destructibility, and hence resistance of the bed of the river, dependent upon the nature of substance forming the bed.

These three factors determine completely the character of the river and give it all the peculiar properties which distinguish it from other rivers, producing the hydraulic phenomena which are observable at any section of its course, such as the momentary level of the surface of the water, the volume which passes the section, the slope of the surface, the local and mean velocities, the wetted perimeter, the quantity of material transported, etc. All these phenomena are only the local results of the three factors already defined.

We shall not undertake a detailed study of the importance and part played by each of these three factors which determine the natural régime of a river, since this would involve too much detail without affecting the result and only complicating the matter. Neither shall we examine critically the first of the three factors indicated, that of the flow dependent upon climatological and geological features of the river basin. These phenomena are undoubtedly extremely interesting in themselves, including, for example, what may be termed the geographical features of the flow in the affluents and the main stream, giving the flood conditions the nature of a wave descending the river; the greater or less rapidity with which the flood wave is propagated, depending upon the state of the banks, and on other conditions; the convexity of head of the wave, a resultant of its accelerating velocity, having the effect of throwing all floating material from the middle of the stream to the banks, and *vice versa*, the concavity of the rear of the wave drawing into the middle all material which follows; the changes which the form of the wave

undergoes in its movement toward the mouth, etc. Nevertheless these phenomena have only an indirect influence upon the condition of the bed, being only causes of the oscillations in the level of the water, which themselves exercise a direct influence upon the bed.

So far as the other two factors are concerned in the determination of the natural régime of a stream, the slope and the resistance of the bed, we shall not pass in review all their details nor the special features of their action upon the bed, but will examine only those points which determine the general characteristics of the river.

Regarding the quantity of water discharged by a river, its flow at any instant is but one element in the entire problem of the distribution of the supply of its entire basin; the slope of the stream at the point under consideration, which itself varies according to local conditions, forms only one detail in the distribution of the whole fall throughout the entire length of the stream.

In descending through a given fall, according to the slope of the valley, the moving mass of water performs the work of trituration and entrainment of the material which has got into the bed of the river; and at the same time the water has to overcome the various obstacles which it meets in its course. When a narrow passage is encountered the water accumulates before it, and re-establishes the general equilibrium of flow by increasing the slope at this particular point above that which preceded it.

When a wide channel is reached the level is lowered, and the consequent reduction in slope at such a point acts to increase the slope of the portion immediately above, so that the rapidity of flow above is increased and that below is diminished. When the stream enters a locality where an inundation prevails a certain portion of the water is left behind until the flood ceases and the level begins to be lowered.

In all these cases, which include the various forms of wetted perimeter of the river bed, the longitudinal slopes of the river are determined in such a manner that the force of gravity acting upon each particle of the mass of water produces an equilibrium between the water arriving from above and that discharged below; the depth and velocity of the current at each point becoming that necessary to establish the general equilibrium involved in the discharge of the water from the region drained by the stream.

But all the conditions of equilibrium which establishes the flow will be deranged as soon as the volume of flow changes and the level of the stream rises or falls.

Let us imagine for a moment that the bed of the stream should become dry, and then suppose that a constant quantity of water should be delivered in a unit of time. During the first elevation of level the water coming down from above would be checked until it had filled the first cavity in the bed; after which it would pass on to the next, filling the second hole, and so on. In a word, as we continued to supply the stream with the same quantity of water per unit of time, its bed would gradually become filled and the slope at every point would change until the moment of equilibrium arrived—that is, until in each section the quantity of water coming from above equaled that passing out below, thus equalling that delivered per unit of time above.

Having determined the level of the surface of the river under these conditions, we have the longitudinal profile, corresponding to the given volume of flow. This profile will have the following property: it will be reproduced every time the river is supplied with the same quantity of water, provided no changes have occurred in the bed, this latter condition affecting the entire profile.

Let us now imagine that the river receives an additional supply of water; we shall have, after the bed has been further filled, a new longitudinal profile, corresponding to the new vol-

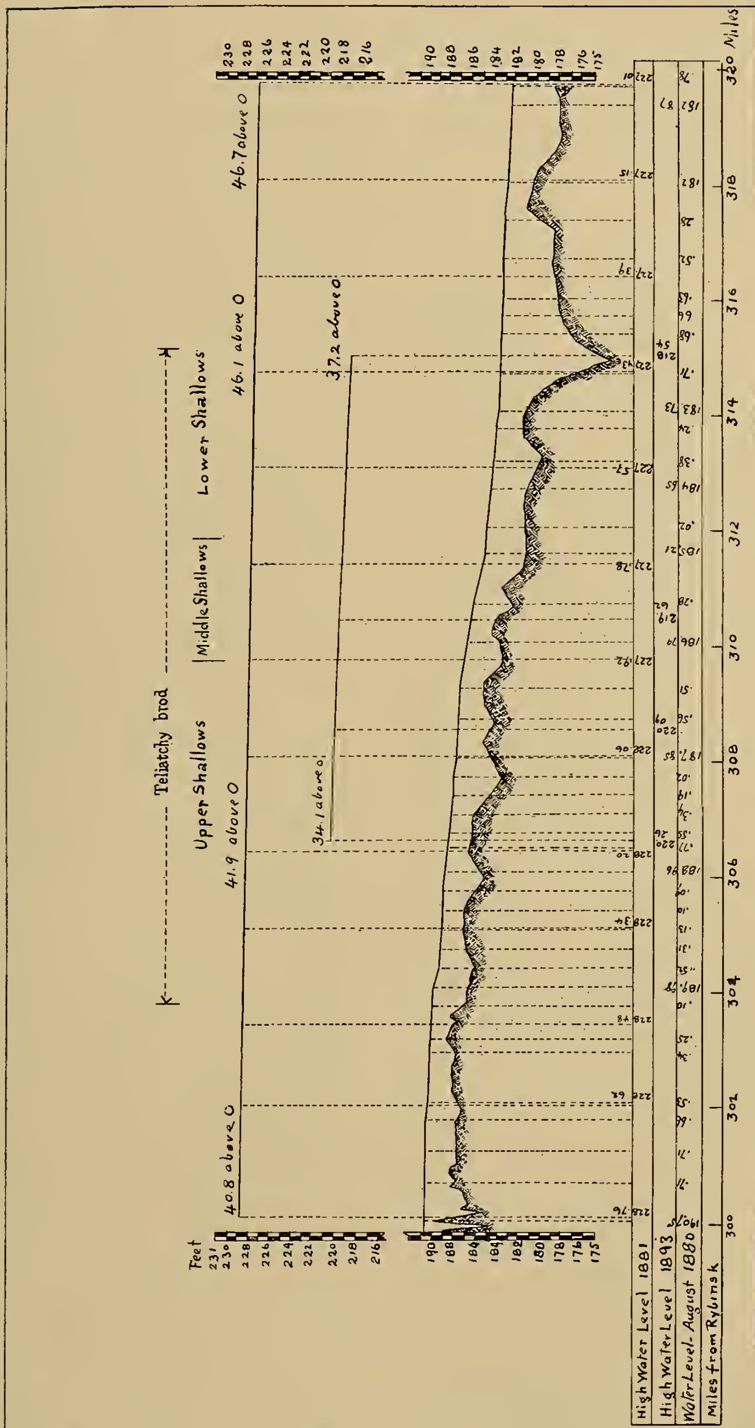
TABLE I.—MAXIMUM HIGH-WATER LEVELS ON THE VOLGA—SPRING OF 1888

Distance from Rybinsk—Miles	Point of Observation	Date	Height Above Low Water—Feet
0	Rybinsk	March 26	37.87
33	Romanovo-Borisoglebsk	....	....
56	Yaroslawl	March 28	34.23
93	Khartcheven	....	....
106	Kostroma	April 4	36.89
142	Ples	April 4	35.63
172	Kinechma	April 4	32.76
212	Yourievetz	April 4	27.72
239	Poutchege	April 8	27.23
268	Gorodetz	April 10	30.94
301	Nijni	April 10	41.02
320	Zimyanskaia	April 10	44.52
350	Issady	April 11	48.65
400	Vassil	April 12	44.66
464	Tcheboksary	April 13	42.42
494	Novaia-Derevnia	April 15	45.50
546	Verkhni-Ouslon	April 15	41.86
594	Bogorodskoie	April 18	43.05
626	Tetiouchi	April 19	43.40
680	Simbirsk	April 21	43.96
787	Morkvachi	April 24	....
826	Samara	April 24	43.75
1,015	Volsk	April 27	42.98
1,095	Saratow	April 27	41.30
1,240	Kamychine	April 30	38.78
1,350	Tzaritzyn	April 30	28.98
1,477	Tchorny-Yar	May 4	31.64
1,560	Enotaevsk	May 6	22.75
1,653	Astrakhan	May 10	11.97

ume of flow, but this profile will not be parallel to the preceding one, because the water encounters new conditions in the bed, demanding a new distribution of slopes to produce equilibrium between the influx and discharge. Thus, in passing from one volume of discharge to another we find each time new forms of current in the stream, characterized by profiles which are not parallel to each other, and each indicating the various obstacles encountered by the water in its movement, for the several volumes of water discharged.

These circumstances furnish what may be termed the point of departure for all reasoning concerning the level of water in a river, or for its depth at any given point in one state or another. In order to give form to this idea let us take an example: Suppose that for a certain increase in the flow of a stream we have a rise in level at a determinate point, this rise will differ altogether from that which occurs at some other point for the same increase in flow, and this relation will be confirmed by the evidence of observation made upon the variations in level made upon the same river. Take, for example, the heights of floods upon the river Volga, at different parts of the stream. In Table I are given the levels of the highest spring floods which had occurred for a period of twenty years (this being in 1888), from which we see that the high level varied between 27.2 feet (at Poutchege) and 45.5 feet (at Novaia Derevnia), there being thus a difference of more than 18.3 feet between the two levels. If it is attempted to attribute this difference, not to the variation in the wetted perimeter, but to the increase in the volume of water due to the supply from affluents, we may call attention to the point that, under such a supposition, the height of the flood level should be the greatest in the lower portion of the stream, while, as a matter of fact, the variations are apparently independent of location, being sometimes more and sometimes less; besides, in the case cited there are no considerable effluents between the points named, and hence no material increase in the volume of water.

In any case, these differences are none the less significant even in small portions of a stream, as, for example, along the length of certain shallows, as we shall see hereafter, these phenomena have an especial importance, while there is no question of possible variations in flow. Without anticipating too much, it will suf-



THE SHALLOWS OF THE RIVER VOLGA—TELIATCHY BROD

fice to cite the profile of the shallows of the Volga, known as the "Teliatchy Brod." In the high water of 1881, the increase of level immediately above the shallows was 40.81 feet, while just below the shallows the increase in level was 46.76 feet, this difference of 5.95 feet being really due to the eddy caused by the contraction of the main channel below.

While considering the importance of the absence of parallelism between the longitudinal profiles of a river corresponding to different volumes of flow, we may make a brief digression and call attention to a consequence of this circumstance: that is, we cannot deduce from a profile obtained by direct measurements, the profile corresponding to a new state of the same stream, by the mere addition or subtraction of the same correction for the entire length of the stream, this correction consisting of the differences in level at a given point for the two states under consideration. Without citing other examples, suppose that we had recorded the profile of depths at the time of the great flood of 1881, and, in order to obtain the profile at low water we had subtracted 46.76 feet from all the depths, this being the rise above low water measured on the scale just below the shallows. As the difference in level just above the shallow was only 40.81 feet, the line drawn parallel to the high water level at a distance of 46.76 feet below would have been 5.95 feet below the true low water level, and would leave the higher points entirely uncovered. This example, leading as it does to an absurdity, shows plainly that to pass from one state of a river to another, it is necessary to make direct measurements of the differences in level at each point, or in other words the longitudinal profile of the stream must be directly determined for each corresponding state.

Here arises the question: how may we determine the profile corresponding to a given volume of flow, since, with the continual changes of level there exists almost no state of uniform velocity over a distance of moderate length? We may observe, however, that it is unnecessary to consider this matter, because the desired level may be determined for a number of points by making the observations along the river, keeping, so to speak, abreast with the water, and noting the effect of the conditions upon the profile; thus, for example, observing the moments of low water, the crest of a flood wave, the interval between two floods, etc.

In any case, whatever may be the means by which the profiles of the river have been determined for different volumes of discharge, they represent, considered as a whole, according to the conditions already cited, the influence of the relief of the riverbed upon the distribution of the slopes, between the limits of extreme low water, and maximum high water. Further, the reciprocal action of the total fall of the river and the distribution of slopes along its length do not limit the influence which this action exercises upon the level of the surface of the water; it is always subordinated to the conditions of equilibrium depending upon the state of the bed at each point.

Having a series of longitudinal profiles corresponding to several volumes of discharge, we will perceive the variations in the slopes at each point in correlation with the oscillations of the level of the water; and we shall also find the location where the slopes increase with the increase in the volume of water as well as the points where under the same conditions the slopes diminish.

The preponderating rôle in the formation of the bed is played by the high waters, because: 1, their velocity is, for the same slope, two or more times greater than the velocities at low water, not taking into account the diminution of frictional resistances; and, 2, because it is during the period of high water that the great bulk of solid material is carried into the bed of the stream, this material being carried in suspension and transported by the velocity of the current, and dis-

tributed along the bed of the river according to local conditions. For this reason the increase in the slope of any portion of a river during high water indicates clearly that no solid matter is being deposited, and that consequently this portion will have a fairly deep bed. Conversely, at the localities where the surface slope diminishes with high water and reaches a minimum with the highest floods, there will occur deposits of the suspended material because of the diminished velocity of the current, causing the formation of sand-bars and shallows.

We shall not go into the details of the circumstances which cause the increase or decrease of the slope with the increase in volume of discharge and produce deep or shallow portions of the bed.

These circumstances vary so much that only a detailed study of each particular locality can enable them to be determined. As we do not desire to enter into these details, we shall cite only a few of the conditions which are more frequently encountered in the majority of rivers, and which produce the more general phenomena.

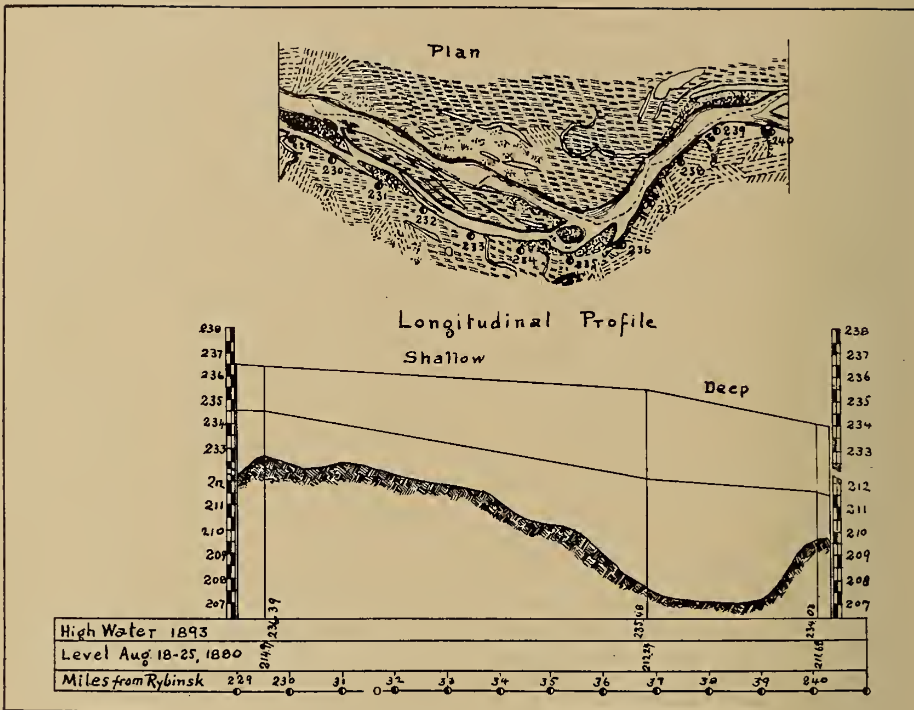
It is well known that in the curves and bends of rivers the bed is almost always regular and deep, and that the shallows are situated on the straighter portions which precede them. This fact, almost a constant phenomenon, has attracted the attention of many hydraulic engineers for a long time. Among them we may mention in the first place the French engineers M. M. Fargue and Dubois, who have attempted to discover by analysis the relation existing between the course of a river and its depth. They have sought the explanation of the phenomenon wholly upon the conditions of continuous flow of low water, notably in the fact that the water tends toward the concave side of a curve, producing a transverse slope upon the surface of the water and a cross undercurrent from the concave to the convex bank. Although this fact is evident, and its influence upon the depth is beyond doubt, it does not furnish an explanation of the formation of the shallows in the straight portions above the curves; neither does it explain why the bed becomes deeper, not only at the curve itself, but also below, when, after a curve more or less pronounced, the river continues to flow, as most frequently at the foot of a mountain, in a direction absolutely straight.

We cannot assume any transverse slope or transverse undercurrent in this latter case. The cause of the facts does not reside in the action of the current at low water, which itself is determined by the form of the bed producing more powerful factors, which change but little, but rather in the action of the current at high water, which, being sufficiently powerful to cause modifications in the bed, act to aid the longitudinal modifications of the profile of the surface of the water.

Each bend or curve, presenting an obstacle to the movement of the water in a direct line, produces an eddy, causing an increase in the slope below and a diminution in that above along the course of the river. During periods of low water, when there is ample room in the bed of the stream for the water flowing, the above cited circumstances can have only a secondary influence upon the distribution of the slopes.

This is not so, however, when with an increase of volume the quantity of water becomes sufficient to be limited by the banks of the stream, and it is under such conditions that the influence of eddies becomes very appreciable, causing the varied distribution of slopes which may readily be observed upon the longitudinal profiles of rivers.

As an example we give the plan of the shallows of Kosten, followed by an abrupt bend, on the River Volga, near Poutchege. As shown in the longitudinal profile, this bend produces a considerable diminution in the level of the river above, con-



THE SHALLOWS OF THE VOLGA AT KOSTEN

sidered with respect to other contractions, and in consequence the slope during high water is greater in the portion below, causing a considerable depth as well as permanence of the bed in this part, although it has not a convex form in plan, but rather a concave shape, so that there can be no question of the influence of centrifugal force. The existence of a higher slope during the period of high water below bends and curves, a consequence of the mechanical conditions of the current, appears to have the character of a general phenomenon, as may be proved by the examination of the longitudinal profile of any river. We may take as a second example the Garonne, which, together with the Rhone, formed the principal subject of the investigations of the engineers Fargue and Dubois. We have the advantage here of the very complete profile covering different heights of water for the portion 56 versts below Lot, published in the *Annales des Ponts et Chaussées* in 1848, edited by the predecessor of M. Fargue, the engineer M. Baumgarten.

We have taken from this profile all the portions corresponding to the curves, and have given in Table II. the corresponding slopes for high and low water. We have for the average of the portion considered:

	Low Water Slope per Kilometre, Metres	High Water Slope per Kilometre, Metres
Average slope for the entire portion	0.2652	0.2652
Slope on the curves....	0.1075	0.3440
Slope on the straight portions	0.4000	0.2610

We see by the above that during low water, when the character of the bed has no influence, the slopes on the curves average about one-fourth those on the straight portions; on the contrary, during high water, by reason of the eddies formed above the curves, they become very considerable, increasing to about three times what they were at low water, and

TABLE II.—SLOPES ON THE CURVED PORTIONS OF THE RIVER GARONNE BELOW THE MOUTH OF THE RIVER LOT

According to the Experiments of M. Baumgarten. Ann. d. Ponts et Chaussées, 1848.

No.	Limits of curves between stations		Fall on the curve when the water is 0.92 metre above the zero datum at Tonniens, Metres	Fall on the curve when the water is 9.32 metres above the zero datum at Tonniens. Metres	Fall for a water level of 7.92 metres
	From km.	to km.			
1	55.0	55.5	0.08	0.20	....
2	56.5	57.5	—0.03	0.37	....
3	59.5	60.5	0.07	0.77	....
4	61.0	61.6	0.14	0.00	....
5	63.0	64.0	0.04	0.63	....
6	65.0	65.5	0.06	0.24	....
7	68.5	69.5	0.05	*—0.02	0.37
8	70.5	72.0	0.07	1.01	....
9	74.5	75.5	—0.01	0.21	....
10	77.0	78.0	0.16	*0.13	0.15
11	79.5	81.0	0.22	0.44	....
12	83.0	83.5	0.03	0.14	....
13	84.0	85.5	0.15	0.27	....
14	86.3	86.9	0.06	0.10	....
15	87.5	92.0	0.59	1.34	....
16	94.0	95.0	0.19	0.34	....
17	97.0	100.0	0.53	0.74	....
18	102.0	103.0	0.14	0.30	....
19	104.0	104.5	0.07	*0.00	0.07
20	105.0	106.5	0.02	0.52	....
21	107.5	108.5	0.07	*—0.03	0.42
Totals	25.2		2.78	7.80	....
Average slope per km. of curve			0.1075	0.3070	†0.3440
Total fall on the remaining 27.4 km. of straight portions			10.93	7.15	....
Average slope per km. of straight portions			0.4000	0.2610	....

Note.—The minus sign indicates a reverse slope.

* On four of the observations the slopes became very low, or even reverse at high water. To verify these exceptions, figures have been added in the last column corresponding to a flood height of 7.92 metres, when we find much higher figures, consequently these four cases do not form exceptions to the general rule that the slopes on curves increase with high water.

† This figure has been obtained by replacing the four doubtful observations of the flood of 9.32 meters by those obtained from the flood of 7.92 metres.

becoming almost one-half greater than on the straight parts. With the increase in the volume of flow the slope changes its place, so to speak, passing from the straight parts to the curves; and since it is during the periods of high water that the principal changes in the bed occur, this fact explains the general phenomenon that the curves, quiet at low water and rapid at high water, have deep beds, while the straight portions which precede them are filled up with deposits because of the reduction in velocity during high water, and present during low water irregularities and rapid slopes.

We may observe the same facts in the longitudinal profile of the Dniester. The portion of this river for a length of 132 miles below Mohilev has an average slope of 0.000189; if we deduct from this length the lengths of all the curved portions and compute the sum of the corresponding slopes, we find that for periods of low water the average slope is 0.000134, while for the straight portions it is 0.000252. Thus we see that on the Dniester, at low water, the slopes on the curves are small, being less than the average slope, while the straight portions show the opposite condition. These relations, however, are wholly changed when we examine the state of affairs at high water. On the curves, where during low water the slope is only 0.000134, and where under such conditions there is a quiet current, the slope rises to 0.000255 at high water, causing an increase in velocity, creating in turn a deep and permanent channel. At the same time, in the straight portions, which during low water have a large slope and more rapid current, the slopes at high water are not more than 0.000174, producing such a retardation in the current that deposits of

sediment are formed in the river bed.

The same effect is produced on the Volga at Saratov.

Another factor which is quite general among the local conditions and which acts also upon the distribution of slopes along the longitudinal profiles of rivers, is the influence of affluents.

Everyone has observed the effect of the material discharged by torrents, particularly in mountainous surroundings. A small rivulet, hardly more than a thread of water, trickling along a bed otherwise dry, becomes an impetuous torrent after each rain, and especially after each storm, carrying into the river quantities of sand, gravel and often even stones. These form cones of refuse, projecting into the bed of the river, these deposits being so well known as to have special names in different localities. After each successive storm the cone becomes larger, and when during low water the river is unable to move the mass, the current is forced toward the opposite bank, which becomes undermined and destroyed by the fall of the upper portions into the stream. When a stream is thus diverted and one bank is attacked, the other shore does not receive the deposits during low water and does not advance towards the side which is being destroyed, but remains in its original condition. In consequence the high water, spreading over the portion of the bed which has been increased by the destruction of the bank, acquires a diminution of slope. With every storm the cone pushes out further and further, and the current at low water is driven over to the opposite side, increasing the width of the main bed and reducing the velocity at high water, causing additional deposits of sediment. After a certain time the main bed becomes so wide that the mass of water loses its cohesion and no longer has a uniform velocity; it finds portions of the bed where it flows with a higher velocity, while at intervals the speed becomes materially diminished, these intervals then receiving the later deposits, and filling up, sometimes with surprising rapidity. Finally, these portions, limited by the banks and currents during high water periods, fill the portions of the bed which are unused at high water, and become islands.

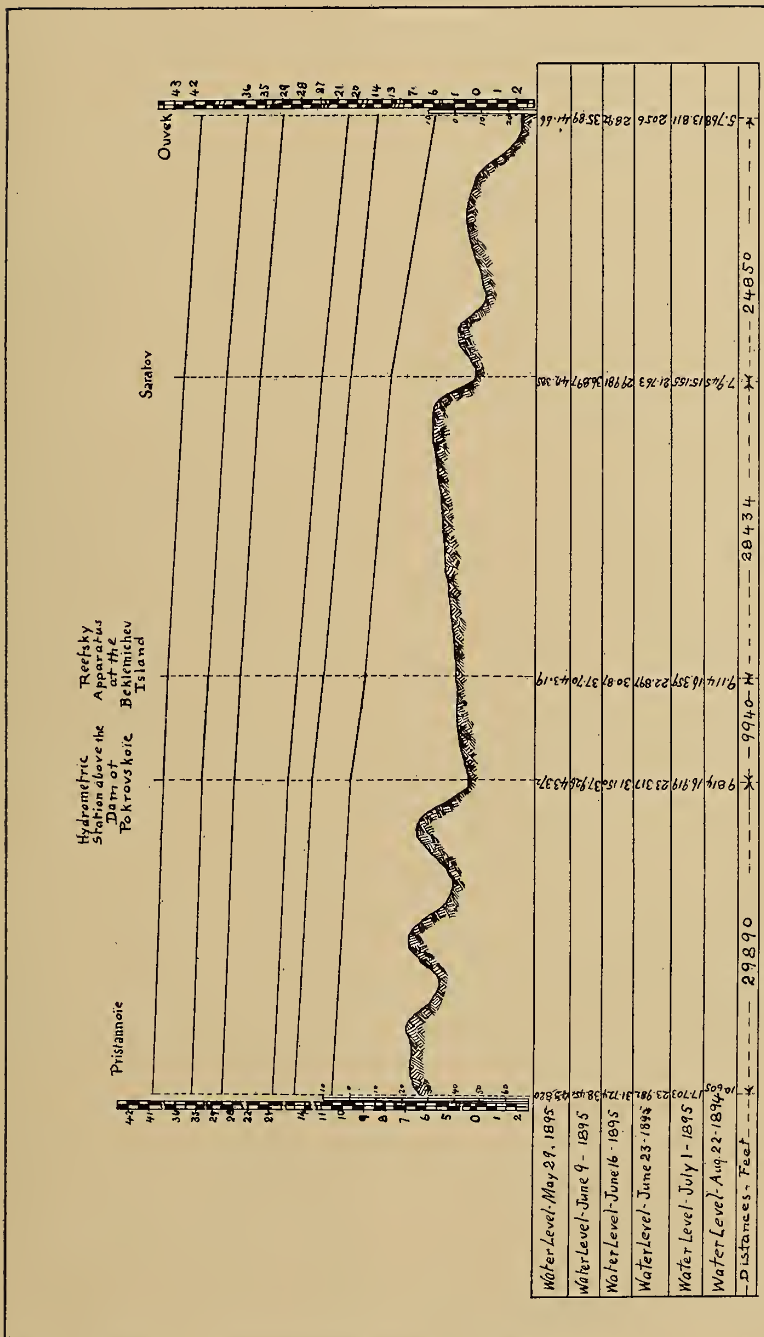
These facts agree with the evidence furnished by the non-coincidence of the channels produced by the currents during high and low water, due to the action of the affluent, which is regulated solely by the influence of the river, its slope, aided by the change in the longitudinal profile.

In order that these effects should be produced, however, forming an irregular bed instead of a regular one, it is not necessary that the affluent should be a torrent, nor that its deposits should be of a rocky nature. Even if it is a tranquil stream, it will nevertheless bring down a certain amount of suspended matter to its mouth. A portion of this will be carried on by the main stream, but the remainder will be deposited and cause the current to be pushed over to the opposite bank, effecting its destruction and recession in a manner similar to that already described.

The existence of islands at the mouths of affluents is a phenomenon very generally observed in rivers, indicating the action of causes at these points tending to produce a diminution of slope at high water, and a consequent deposit of suspended matter.

As a third factor among the local influences upon the longitudinal profile of a river, we may cite the lack of homogeneity in the soil at different portions of the bed. Leaving out of consideration those portions in which the banks are formed of bare rock, and considering only the general case, we may say that whatever the resistance of the banks, they will be attacked by the river, even when the stream is in a certain measure repelled, or the current or the ice is forced against them, as, for example in curves.

Although this recession of the bank



LONGITUDINAL DIAGRAM OF THE RIVER VOLGA AT SARATOV

is accompanied with a simultaneous displacement of the currents at high and low water, the new portion of the main bed which is not necessary to carry off the high water becomes filled up, not by the formation of islands, as described above, but by the normal increase of the abandoned bank, an increase which is effected simultaneously with the recession by the aid of the deposits which occur even at low water. The abandoned bank thus advances towards the stream as the opposite bank recedes, in such a manner as to maintain at all times the regularity of the bed and the same distribution of slope on the longitudinal profile. This will not be the result if the front of the bank forms a compact mass, consisting of clay, puddingstone, etc. The movement of the stream against the bank attacks the upper layers more easily, and while these are destroyed, the lower and harder portions will resist, thus preventing the channel at low water from following that occupied at high water in the new and enlarged bed. This will prevent the formation of deposits on the opposite bank, because the channel at low water will be maintained there; thus the main bed becomes enlarged on one side without being diminished on the other. When, with the fall in the level from periods of high water, the velocity of the current is reduced in the wide bed, the formation of deposits will result in the production of bars, followed by the same effect as appears with natural or artificial dams, checking the destructive action of the river.

Whatever may be the causes which produce different slopes at low and at high water, and whatever may be their variety, each local slope, changing with the oscillations in level, forms but one element in the equilibrium profile of a river. The local slopes produce certain effects upon the bed in their several localities, according as they are increased or diminished with the rise or fall of the water level. As we have already said, it is the high water which dominates the formation of the bed of a stream and gives it its form, both because of the kinetic energy of the mass of water and because of its increased velocity. If, in descending the course of a stream, the high water encountered everywhere the same conditions, the effects would be distributed in a uniform manner, and the bed would have a uniform slope, as we shall see in the case of a stream traversing a uniform soil.

Leaving aside this special case, we may affirm that in each river, among the factors which control the distribution of its longitudinal slopes, there is an intimate dependence upon the nature of the bed or valley through which the stream runs, and this cannot be materially eliminated or modified in any manner. For example, it is impossible to change the general plan of the river, altering the curves in direction or the variations in its beds when it passes among high mountains or when it is confined between rocky banks. Doubtless certain parts of the banks are more readily attacked than others, permitting their destruction or enlargement, and under such conditions it is impracticable to consider uniform slopes at high water along the entire length of the bed. The inevitable consequence is the subdivision of the river into portions having slopes either great or less than the average, and having determinate beds and depths in the portions where the current is rapid at high water, and formation of sediment at the point where, owing to the diminution of slope, the energy of the high water is diminished and the solid materials are deposited.

Apart from the consideration of the subject of longitudinal slopes, it is necessary, if we desire to penetrate still further the causes of this phenomenon, to apply the third of the factors cited at the commencement of the present paper as governing the natural condition of a river, namely, the properties of the material of the bed from the point of view of its resistance to destruction, and to the formation of material to be carried

along by the stream and deposited elsewhere in its bed.

Every river, whatever its course, and whatever the regions which it traverses, is the route by which the water falling upon the surface of its basin reaches the sea, and it is also the means for the transport of the solid material which descends with the water.

According to the most remote historical records, rivers have at all times possessed the same general nature as they have to-day; in all cases the dimensions of their beds have been no less than they now are, and their banks and their beds, speaking of them in their entirety, and not of isolated portions, have not been destroyed or self-destroying, hence they cannot have been the origin of the material which has descended with the water, the accumulations of which have attained such considerable dimensions at the estuaries.

The suspended matter has not been supplied by the river from the destruction of its banks or removed from its bed, according to the generally conceived opinion. It reaches the river together with the water from the entire surface of the basin, and its quantity does not depend upon the nature of the bed; it is an inevitable arrival, and its properties and constitution arrive with it, while the river itself acts to triturate it by the friction of the particles, so that the mass determines the character of the stream.

The total fall of a river determines the value of its slopes as well as its velocity and the destructive character of the current. The properties of the valley, the bottom, and the banks of a river oppose, on the one part, a certain resistance to the destructive action of the current; and this resistance retains the mass of moving water within the limits of its bed. These two natural elements, the steepness of the slope and the resistance of the bed, are wholly independent of each other, and notwithstanding the diversity of their mutual reactions, they always maintain their equilibrium with each other; this is the reason why rivers remain at the present time in the same general locations in which they have been in the past. We may therefore examine how this equilibrium has been established under such contradictory circumstances, such, for example, as in the case of a river having a steep slope and a bed of low resistance, or in the case of a stream with a small slope and a very resistant bed.

When a river has a resistant bed and a small slope, its comparatively slow current is unable to displace the material which is deposited upon its bottom, except in such portions where, by reason of some local cause, the high-water slope is relatively considerable, as on curves and in contracted portions. In places where the velocity of the current is accelerated at high water, the deposits, or at least the finer portions, are carried down the stream during the high-water period, but upon their arrival at the places where the slope is smaller the suspended matter is again deposited, the coarser matter coming down first and finer portions afterwards.

At each high-water period the masses of deposited matter are displaced in this manner, and hence, after a certain number of successions of high or low water, there will be formed a deep channel along the steeper slope, and an obstruction in the bed produced by the accumulation of the larger particles in the portions where the slopes are smaller.

Every obstruction of this kind, however, has its limits, because each new layer of deposit corresponds to a further increase in the low-water level, and consequently in the destructive energy of the current, which thus finally become sufficiently strong to carry away, in the interval between two floods, the material which has been deposited in this shallow.

(To be concluded.)

MODERN COTTON-MILL EFFICIENCY

SAFETY APPLIANCES IN CARDING, DRAWING, AND ROVING MACHINERY

By H. M. Crawford

THE cardroom of an up-to-date cotton mill is a striking combination of mechanical energies. It bristles with wheels and willing workers in never-ceasing activity; and were it not for the occurrence of unfortunate accidents in this department the thousands of operatives employed might, as a rule, be envied their occupation.

A modern cardroom, preparing yarn for a mill of 80,000 mule-spindles, contains approximately the following machinery:

Eighty revolving flat carding engines, with 50-inch cylinders.

Eight drawing frames, each having three heads of seven deliveries.

Eight slubbing frames of ninety spindles.

Sixteen intermediate frames of 136 spindles.

Forty roving frames of 180 spindles.

We may thus count on at least 150 complete machines preparing the cotton for the final process of spinning on mules or ring-frames. Slubbing, intermediate and roving frames are generally known as "speed frames" or "speeds"; and these in the mill under consideration will contain some 10,000 spindles, each operating a bobbin on which the yarn is spun and wound.

The treatment of cotton in a cardroom is interesting and may be briefly described.

When raw cotton reaches the factory it appears in close-packed bales averaging in weight 672 pounds. With bale-breaking machines and cotton openers its fibres are loosened and made to occupy greater bulk. The material is well beaten in the scutcher, and treated to powerful fan currents for the purpose of eliminating dust, knots and tree-fibre. It then appears as a rolled cylindrical "lap." (Fig. 1.)

This "lap" is the first form in which cotton enters the cardroom; and its first machine is the carding engine. These machines are arranged in two or three parallel lines (Fig. 2), extending the entire length of the room. The lap is fitted into receiving-slots at the back of the machine, and is unrolled by means of a traveling apron.

FIG. 1.—LAP OF COTTON READY FOR CARDING

This passes under the feed roller and leads to a cylinder—the "licker-in" —covered with saw teeth to the tune of several hundreds. The licker-in, otherwise known as the "taker-in," impinges the fibres, casting from the cotton numberless "neps," or knots, and short fibres, which would be detrimental to the finished yarn. The cotton is then passed to the main cylinder of the machine; this is made of cast-iron, is about 40 inches wide and 45 to 50 inches in diameter. It is covered with card-fillet, *i. e.*, a narrow strip of cloth in which points of steel wire have been pierced by special card-making machinery. On a single

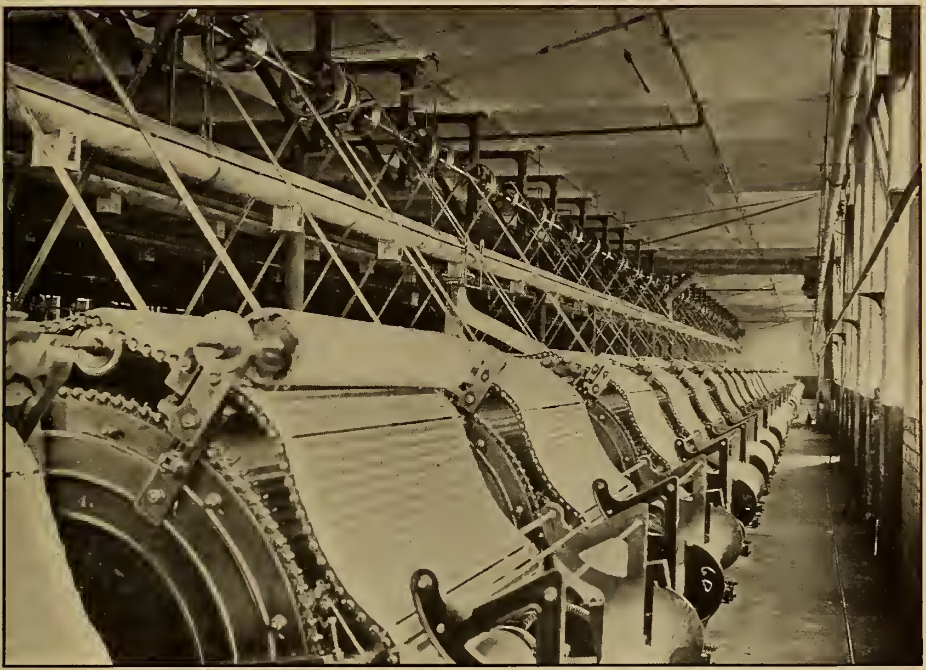


FIG. 2.—LINE OF CARDING ENGINES IN A MODERN COTTON MILL

cylinder the total length of the fillet approximates to 260 feet, which occupies 8 days, of 10 hours, in the making, and contains upwards of 1,000,000 wire points.

The fillet is wound upon the cylinder at a tension of from 230 to 260 pounds, so that, when completed, the whole cylinder appears as a solid entity covered with steel points. These take the cotton fibres from the licker-in, tear them asunder, and act as one vast comb laying the fibres in a parallel direction.

Another cylinder—the "doffer"—follows the main cylinder. It is 20 to 24 inches in diameter, is also covered with card wires and revolves opposite to, and about one-twelfth the speed of, the main cylinder. This smaller cylinder "doffs" or removes the fibre from the main cylinder and further promotes the parallelism of the material. With a remarkably fine edge a stripping plate releases the cotton from the doffer; this is collected by a bell-shaped receiver and forms a thick, fluffy thread known as "sliver."

Four-feet cans hold the sliver, which is slightly coiled by the mechanism of the carding engine, and then transferred to the drawing frame. (Fig. 3.)

Drawing frames generally have their *locus* in the center of the cardroom. It is of the utmost import in the economic working of a cotton mill that drawing frames should be readily accessible from the carding engines, and be in close proximity to the speed frames which they are to feed. Hence two or three lines of drawing frames occupy the whole length of the middle portion of a cardroom. These machines are simple in their operations. Four to eight slivers are passed through four pairs of rollers revolving at varying speeds and thus attenuating the cotton. The slivers are also combined to make a stronger one on the "delivery" or exit side of the machine. In a frame of three heads and seven deliveries we have 21 resultant slivers drawn from 80 to 160 slivers from the carding engine.

The drawing frame, by attenuating

FIG. 3.—PLACING THE SLIVERS ON DRAWING FRAME

and further parallelizing the fibres, prepares the cotton for the first process of spinning on the slubbing frame.

The "slubber," as this machine is termed in brief, receives the slivers in cans from the delivery side of the drawing frame. Each sliver passes through rollers, which further attenuate the fibres, and is spun on the apex of a rapidly revolving spindle. Simultaneously the spun thread is wound on a wooden bobbin. "Slubber" bobbins are transferred to the intermediate frames (Fig. 4), where two threads are combined into one and the resultant is spun finer still and wound on a bobbin. The same process is adopted in the roving frame; so that the thread, when it leaves the roving frame, is strong and comparatively fine.

The processes of the cardroom terminate here. From the rolled lap of heterogeneous raw cotton we have manufactured a thread, uniform in strength and thickness, ready for the self-acting mule.

Now in all these processes, intricate but useful and necessary, there are certain elements of risk, which can be alleviated by means of well-considered safety appliances. These are as necessary as the machines; they operate materially in saving life and limb, and in reducing the casualty bill. Both insurers and insured are aware that a single casualty may involve expense running to three figures; and it is equally certain that

FIG. 4.—AT WORK ON AN INTERMEDIATE FRAME

£100 may be saved at the expense of a safety appliance costing a single shilling. If the enormous disproportion between the cost of an accident and that of a "guard" is carefully considered, there should be no apathy with the general trend of safe-guarding.

The cardroom has been prolific in casualties more or less serious. The number of reported accidents will illustrate:

	1900	1906	1907	1908
Carding engines......	242	268	348	371
Drawing frames......	47	67	80	70
Speed frames	270	359	420	394

In "fine-spinning" mills, where combing is carried on in addition to the processes already described, the combers have been responsible for the following casualties:

1900	1906	1907	1908
35	67	82	60

Authentic details such as these afford ample proof of the advisability of adopting preventive appliances wherever reasonably practicable. In the totality of the accident roll carding engines and speed frames hold prominent positions; and there can be little doubt that a large proportion of these casualties may be avoided by the adoption of secure fencing and by constant care on the part of those responsible for its efficiency.

The greatest danger in the carding engine is concerned with the million points of steel wire (Fig. 5) which encompass the main cylinder. The wires are ground laterally for about

FIG. 5.—MICRO-PHOTOGRAPH OF CARD WIRE

one-sixth of an inch near the points, and edge-wise; so that each point in magnified form has the appearance of a formidable knife blade. Besides, in the process of grinding the *edge* of the wire, it frequently happens that a small hook of steel is projected immediately over the point. Now as these wire points, with their incumbent hooklets, move towards the worker when the cylinder is revolving, it will be clear that if these hooklets collide with any intervening hand or finger serious injury may ensue. Not serious, of course, from one or two wire points, but from *many;* for we must remember that over the space of an operative's hand not less than 2,000 of these act in concert, and all contribute to the injury. This form of casualty is so serious, in fact, that no effort should be spared on the part of employers to render it impossible. It happens during the process of stripping the wires of dust, neps and short fibres. Three or four times per day a cylindrical wire brush is applied to the card wires (Fig. 6.), for the purpose of cleaning or "stripping" them. They are covered with hinged steel plates during ordinary carding operations, and no risk ensues; but before the stripping brush can be applied the steel-plate cover must be removed. It is levered up or down, according as the cover is hinged above or below. Then a portion of the main cylinder is exposed. The stripping brush is applied and revolves at a rapid rate, while the cylinder is slowed down considerably. If the cover were closed immediately after the removal of the stripping brush the risk of accident would be eliminated; but the closure of the cover is at times inadvertently omitted, while the carding cylinder rapidly gains speed to 160 revolutions per minute. Thus the wire points in a 50-inch cylinder move past the fixed edge of the doffer plate at the rate of 30 feet per second.

Simultaneously with this accession of speed another element contributes

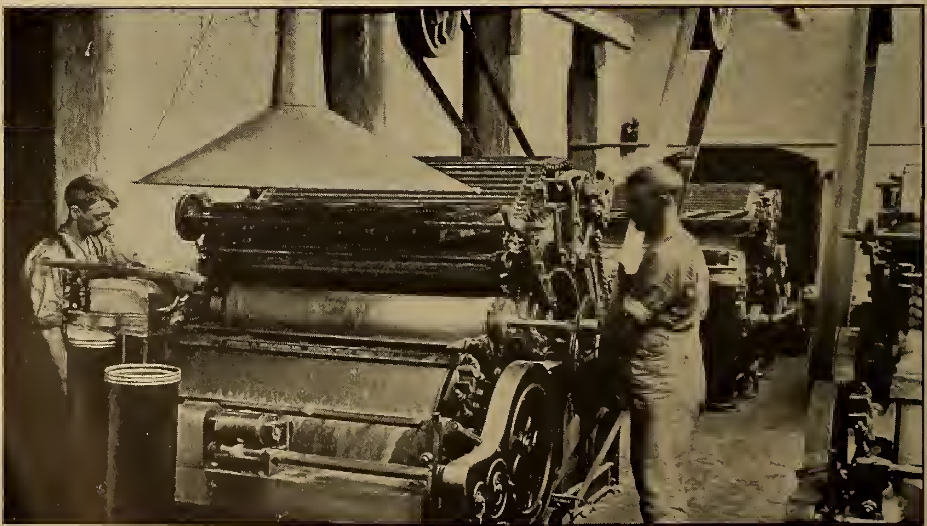


FIG. 6.—THE STRIPPING PROCESS ON A CARDING ENGINE

FIG. 7.—REMOVING THE CURTAIN FROM A CARDING ENGINE

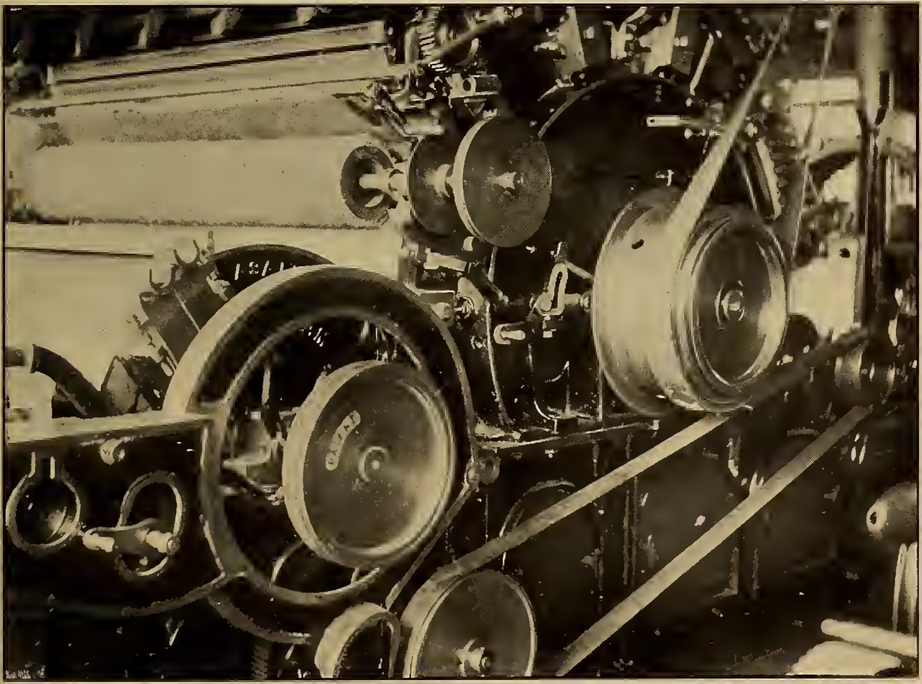


FIG. 8.—LOCKING ARRANGEMENTS ON A CARDING MACHINE WITH STRIPPING BRUSH IN POSITION

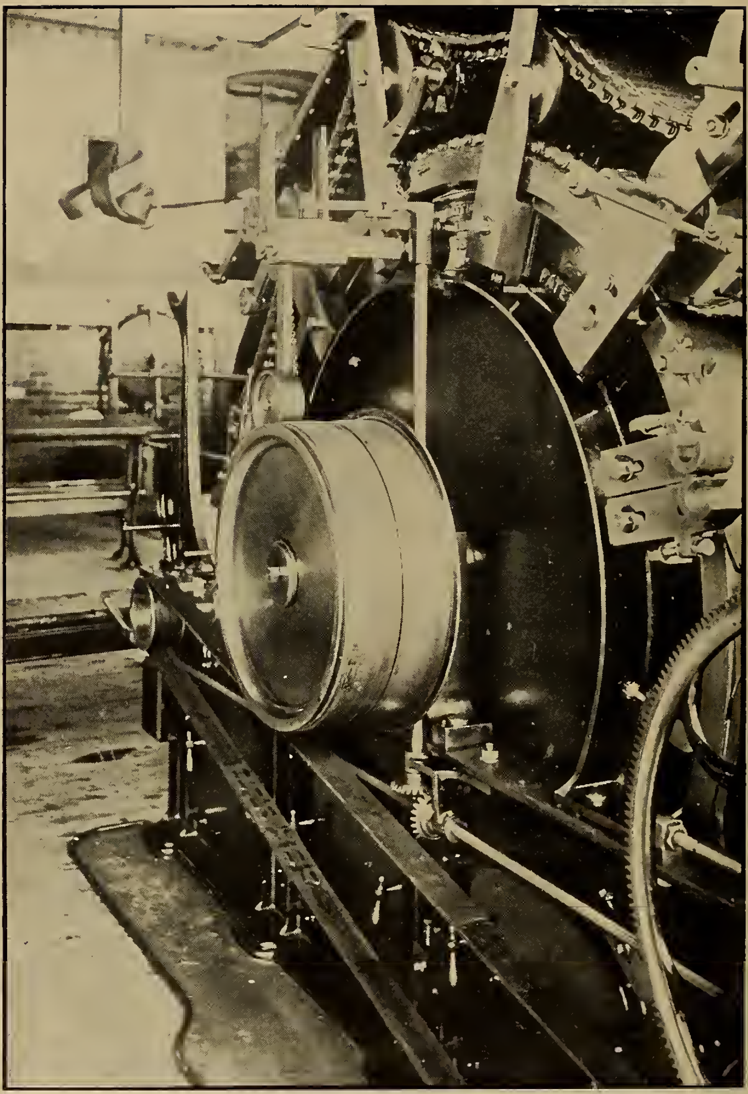


FIG. 9.—STRAP FORK ON CARDING ENGINE

This may be operated from either side of machine.

to the gathering danger. Strips of loose cotton (Fig. 7) are formed by the card comb, much like a striated curtain, which gradually falls over the front of the uncovered card wires and obstructs them from the view of the worker. And as this fibrous curtain must be removed by the operative's hand close to the seat of danger, the probable occurrence will be obvious. In several instances the hand of the worker has been seized by the wire points and so severely injured as to necessitate amputation.

Happily this form of accident bids for entire suppression with the appliances (Fig. 8) now being formulated. These are to fulfil two essential requirements laid down by the Federation of Master Cotton Spinners' Associations in a letter to its members in 1908. The recommendations refer to

locking arrangements for carding engines, which should comply with the two following conditions:

1. They must prevent the cover being opened until the cylinder has ceased to run; and

2. They must render it impossible to restart the card (*i. e.*, carding engine) until the cover has been closed. By the maintenance of these conditions there can be no access, even inadvertently, to the dangerous wire points while the cylinder is revolving towards the worker. The accidents referred to cannot then happen.

It is quite true that the cover must be removed for the occasional application of a small emery roller to grind the edges of the wires, but then the cylinder will revolve in a direction away from the worker, and will occasion no risk.

These automatic locking arrangements are already completed in over twenty important mills; while many more have provided lockers on a considerable number of their machines. It thus follows that the incidence of accident from these card-cylinders is narrowing, and with the complete installation of lockers the most serious of carding-engine casualties will become extinct.

We now come to deal with the driving pulleys of carding engines and the availability of strap forks for moving the driving strap from fast to loose pulley and *vice versa*. The general custom is to transfer the strap by hand; but there must necessarily be some danger attending this operation. The hand may be caught between the strap and the pulley, in which case the injury is unlikely to be trivial.

To obviate such risk, strap forks have been adopted in several cotton mills, so that the strap can be transferred without manual contact. In Fig. 9 a strap fork is shown which may be actuated from either back or front of the carding engine; a horizontal shaft, with terminal handles, is geared to an upright rod, this is levered to the sliding bracket which bears the prongs of the fork. It is

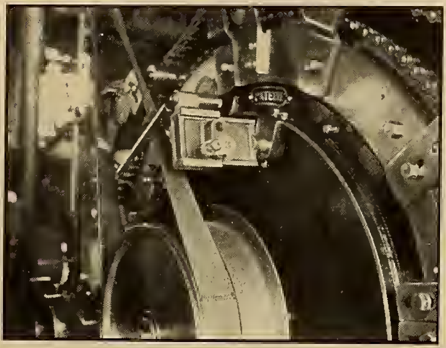


FIG. 10.—STRAP-FORK LEVERED INTO POSITION ON A CARDING ENGINE

thus possible to manipulate the strap several feet away.

When the card wires are submitted to the grinding roller, the driving strap is removed for reversed running of the cylinder; but even then the hand need approach the driving pulley only when the strap is reapplied. Strap forks are adequately fitted with handles (Fig. 10), which make their working easy and practicable.

The spur and bevel gearing of carding engines have shown a comparative diminution in the casualty roll since the general adoption of safeguards. Fencing of these wheels is usually completed by the makers of the machine; but in respect of types made 20 to 30 years ago, and still running, important additions have been made to the old guards. When cleaning, by hand, of certain parts of the machine is done while the machine, as a whole, is in motion, it is absolutely necessary that secure fencing should be provided for dangerous wheels near to the parts so cleaned. Doffer and carrier wheels (Fig. 19) are now well fenced in most machines. Draw-box wheels are also carefully cased over. Calendar wheels have, in former days, had a heavy toll of accidents to fingers; these wheels are now fenced on all sides, so that nothing short of removal of the guards can lead to injury (Fig. 12).

One important item is sometimes omitted in regard to the "taker-in" cover of the carding engine. It may

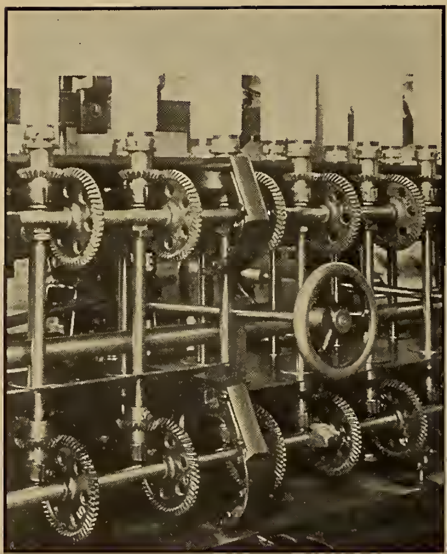


FIG. 17.—BOBBIN AND SPINDLE SHAFTS OF SPEED FRAME, SHOWING SKEW BEVELS

be requisite to remove the cover for the abstraction of hard accumulations of cotton; and, at times, the cover is lifted before the taker-in (Fig. 13) is quite stationary. Such procedure is fraught with great danger; and, to minimize the risk, covers are generally screwed to the frame of the machine (Fig. 14). If then the driving strap be placed on the loose pulley sufficient time will elapse for the taker-in to cease running while the screws are being released.

The taker-in is a cast-iron cylinder, about 9 inches in diameter, in front of main carding cylinder, to which it gives the fibrous material. It is covered with serrated steel teeth, as shown in Fig. 13, which are inserted spirally in grooves cut into the surface of the cylinder. This arrangement facilitates the division of the fibres of the lap as they pass under the feed roller. As the taker-in revolves at a speed of 350 to 400 revolutions per minute there can be no doubt as to the danger of approaching it when uncovered.

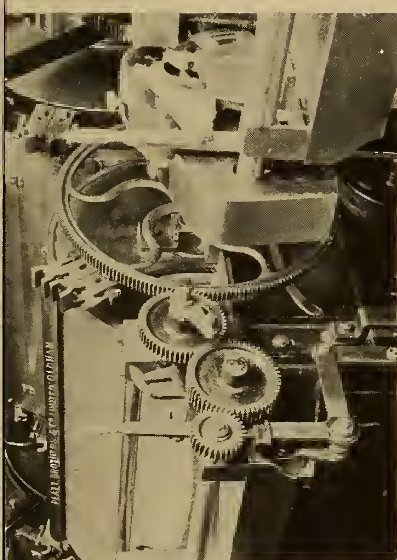
Drawing frames have much less to answer for in the way of accidents. There is less liability of moving parts coming into collision with operatives' fingers. The most dangerous factors (Fig. 15)—the calendar and draught roller wheels—are adequately fenced by cast-iron guards (Fig. 16), so fixed and levered to the machine frame that casualties are well-nigh impossible, unless the guards be turned entirely out of their proper place. If this *were* done, the guard is of such nature and magnitude that it could not escape the eye of the worker. In the most recent machines even this exigency is obviated by providing a locking appliance to maintain the guard *in situ* so long as the machine is in motion.

The under-shafts of drawing frames are occasional sources of injury. These shafts revolve near the floor at 150 to 200 per minute. Female labour is employed on these machines, and when cleaning near the shafts the aprons and skirts of the workers are apt to be coiled round, thus dragging the worker to the floor, with consequent injury. Where undershafts are encased with metallic guards such accidents are impossible. The driving-pulley, too, at the frame-ends are unduly exposed when unfenced, and unwary operatives have been involved thereby. A simple form of fender guard meets the difficulty, and workers may pass and repass in perfect confidence.

The highest average of accidents in the card-room is concerned with "speed frames," slubbers, intermediates and rovers. These are three grades of the same form of machine. Slubbers are the slowest type of speed-frame, and receive the sliver in cans from the drawing-frame, to be spun and wound on bobbins. Intermediates receive the bobbins of yarn of the slubbers and spin it on finer bobbins. Rovers take the intermediate yarn and spin it into a finer thread still.

The rates of motion on these several machines are:—

	Revolutions per Minute
Slubbing-frame spindles	700 to 800
Intermediate-frame spindles	800 to 900
Roving-frame spindles	900 to 1,100



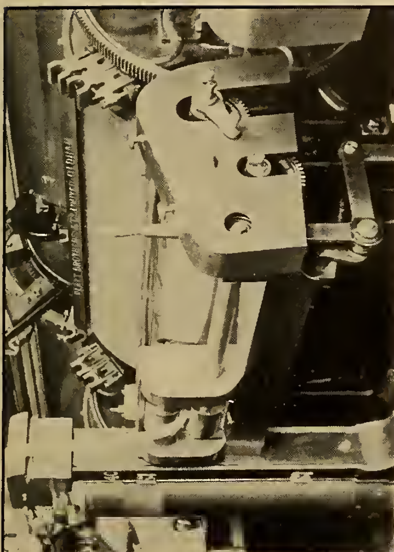


FIG. 11.—DOFFER AND CARRIER WHEELS ON CARDING ENGINE

FIG. 12.—GUARDS ON DOFFER AND CARRIER WHEELS OF CARDING ENGINE

FIG. 13.—THE TAKER-IN CYLINDER, COVERED WITH SAW TEETH

FIG. 14.—TAKER-IN COVER SCREWED TO FRAME OF MACHINE

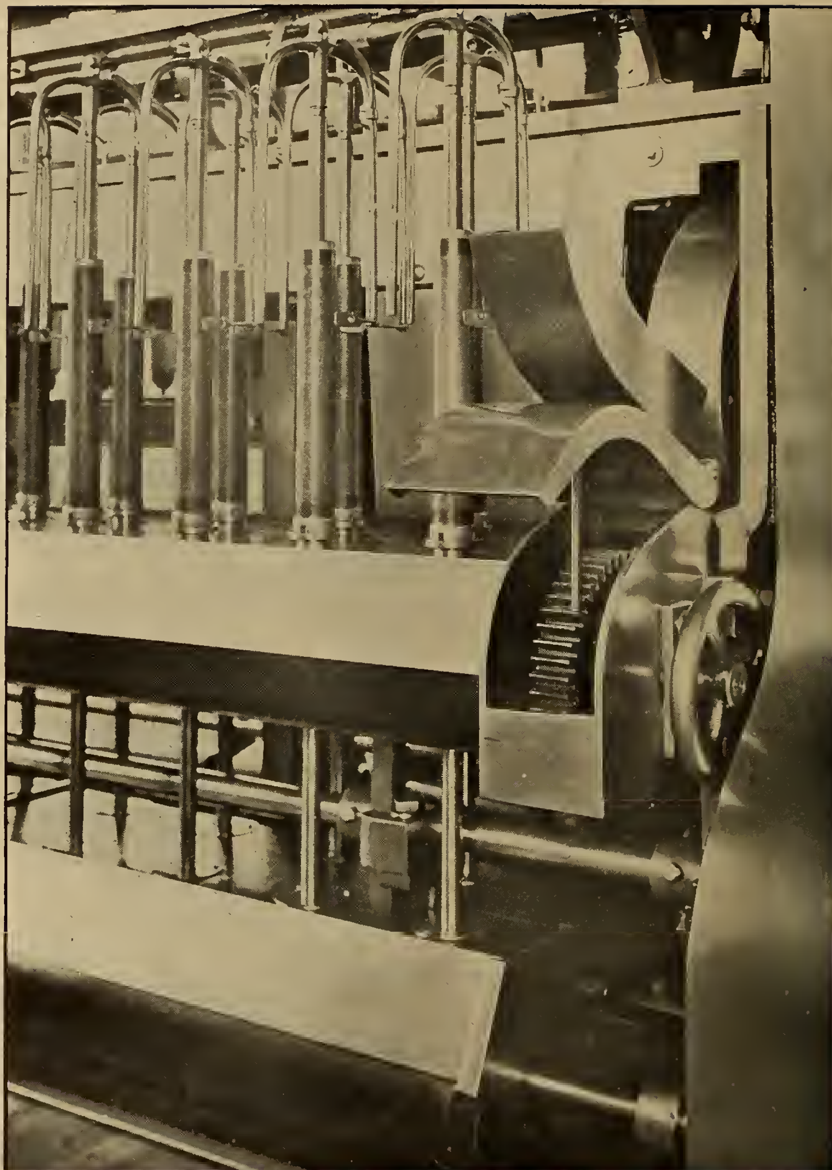


FIG. 18.—GUARDS OVER BOBBIN AND SPINDLE WHEELS OF SPEED FRAME

The spindles appear on the front of the machine (Fig. 17) in close proximity to the worker, and are connected with two horizontal shafts, one near the floor, the spindle shaft, and one immediately under the bobbins, known as the bobbin-shaft. On each shaft a skew-bevel operates every spindle and bobbin. In a roving frame of 180 spindles we have thus 360 bevels (the driving and the driven wheels) to the spindle-shaft, and the like number to the bobbin-shaft, or a total of 720 toothed wheels. Furthermore, each shaft-bevel is fixed to the shaft itself by three screws with projecting square heads. Clearly, therefore,

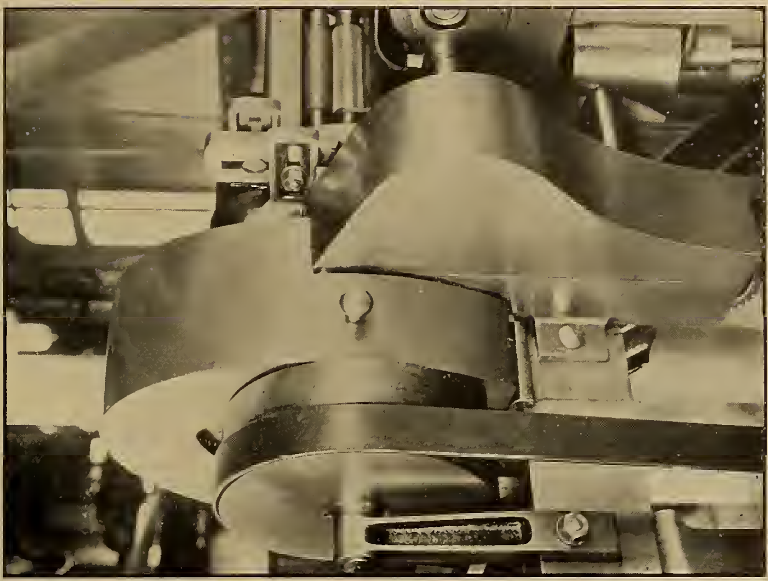


FIG. 16.—GUARDS ON ROLLER WHEELS ON DRAWING FRAME

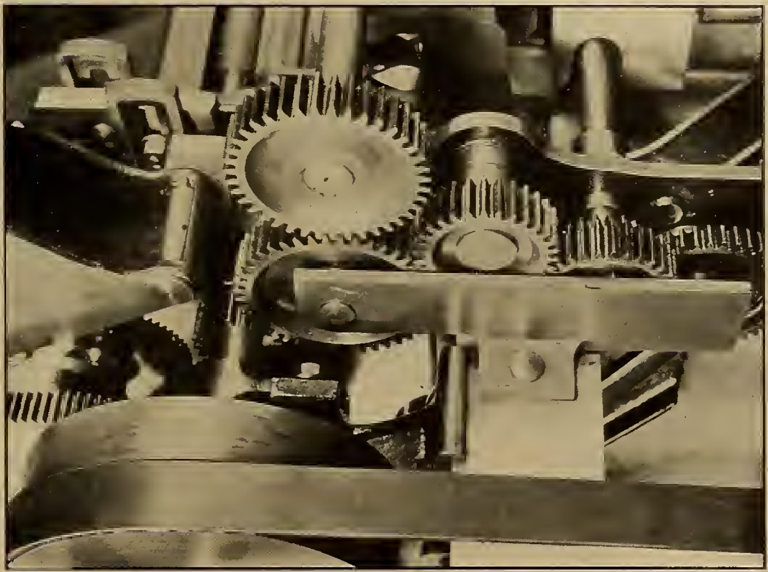


FIG. 15.—ROLLER WHEELS OF A DRAWING FRAME

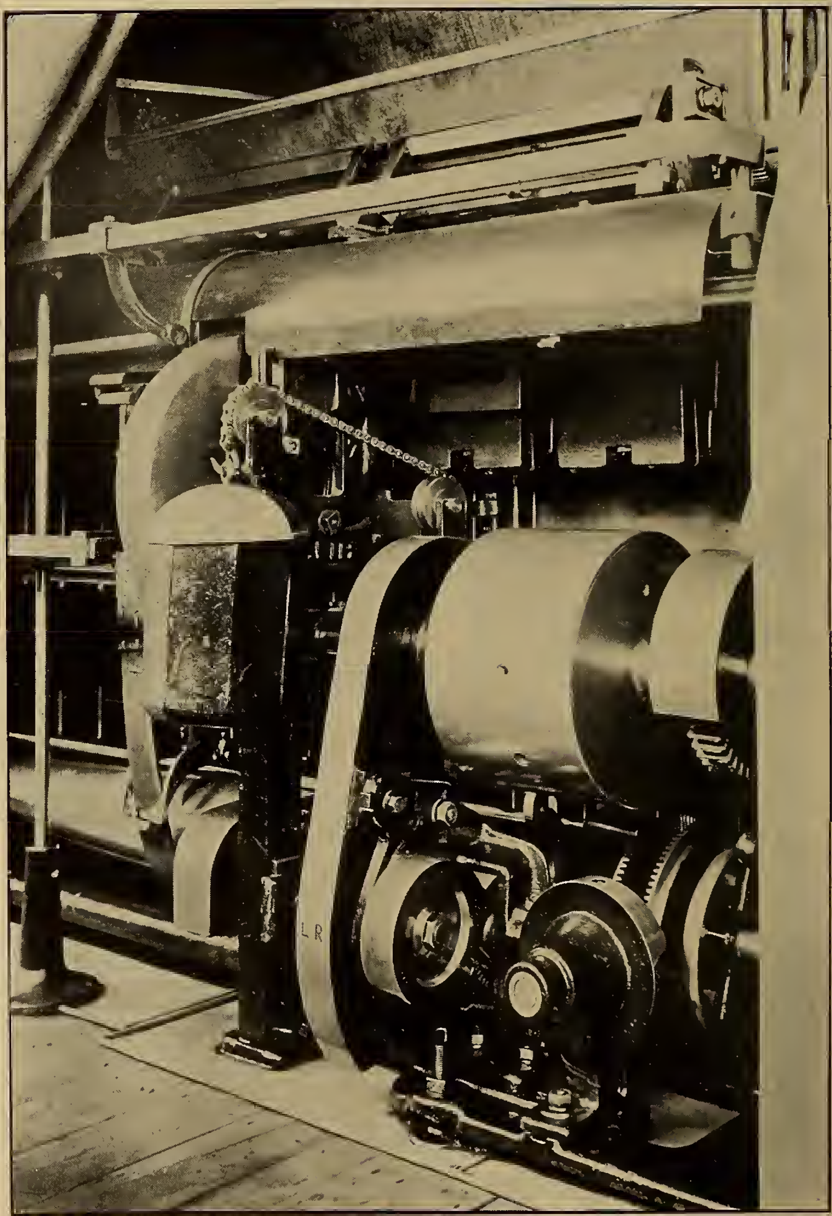


FIG. 19.—GUARDS OVER DIFFERENT WHEEL TRAINS IN THE HEADSTOCK OF A SPEED FRAME

these bobbin and spindle-shafts bristle with danger-points from end to end, and safe working would be impossible if fencing were omitted. The present method of guarding is adequate for ordinary purposes of spinning. Plates of steel, or wooden flats, cover the top of the shafts; a slanting steel plate fitted in slots covers the upper front nearest the worker, and a curved steel plate covers the lower front (Fig 18). On the spindle-shaft the back is covered entirely by plates reaching to the floor. The bobbin-shaft has a cover for the upper back only. The lower back and

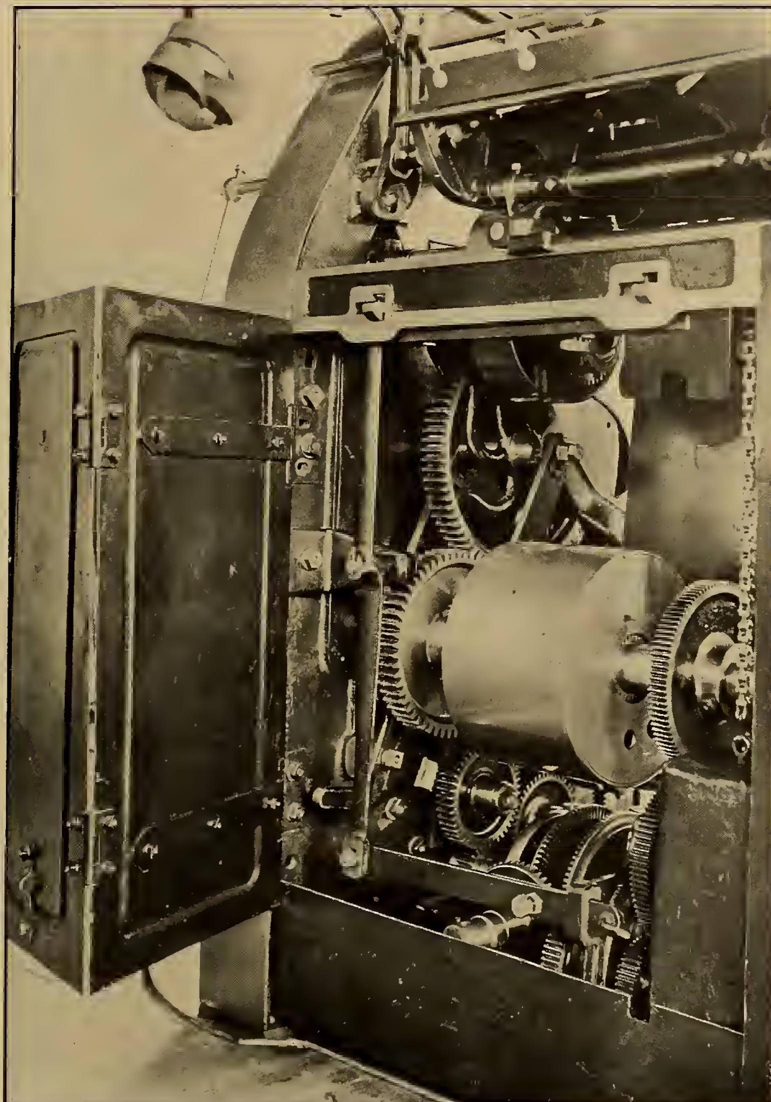


FIG. 20.—SAFETY-LOCKING DOOR OF HEADSTOCK GEARING OF SPEED FRAME

the under sides are generally open, leaving an interval of four inches between the front plate and the midrib dividing the two lines of spindles, and six inches between the midrib and the back plate. And it is in this 10-inch interval that the most severe bobbin-wheel accidents occur. The operatives clean the adjacent guards and stationary parts of the machine while the latter is in motion; cleaning cloths are captured by the projecting screw-heads and by the skew-bevel teeth. Fingers follow the cloth, and injury ensues before the worker can extricate herself. With spindles revolving at 700 to 1100 it will be evident that the injury is the work of a moment, and gives the person concerned little chance of escape. If the 10-inch space can be adequately covered, the operative's safety in cleaning will be considerably enhanced. Efforts are already under considera-

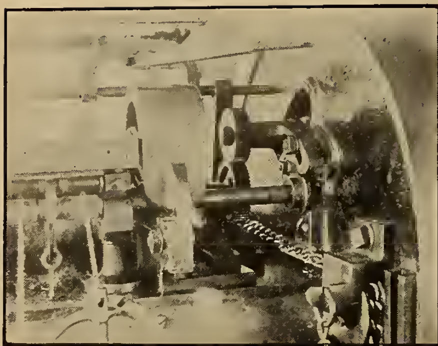


FIG. 21.—DRAFT WHEEL OF SPEED FRAME

tion to effect this needed improvement.

The headstock (Fig. 19), or driving part of the speed-frame, is a composite of mechanism which is admittedly dangerous if unprotected. The wheels herein are spurred or beveled with finely-cut teeth, and accidents from these have been numerous and severe. Up to recent years a method of fencing was in vogue which shielded *parts* of each dangerous train of wheels. These guards doubtless saved accidents to operatives engaged in cleaning the headstocks. Twist-wheels, sun-and-planet wheels, swing-wheels, lifter-wheels, were dealt with well at the ingathering points, but parts adjacent were not so adequately protected as to prevent accidents.

The modern type of headstock guard (Fig. 20), bids for universal adoption, inasmuch as it is doubly preventive. An automatic door closes over the whole of the headstock gearing, and this cannot be opened so long as the machine is in motion. Besides, the machine cannot be set in motion until this iron plate door is shut. The effect of this appliance has been most salutary.

But perhaps the most striking instance of the efficiency of a guard is seen in the draft-change wheels (Fig. 21). These operate the rollers attenuating the threads of cotton as it passes through the machine. In many large factories these wheels were entirely unprotected, and severe accidents were frequent, some involving the loss of fingers. Now these wheels are universally fenced (Fig. 22), and

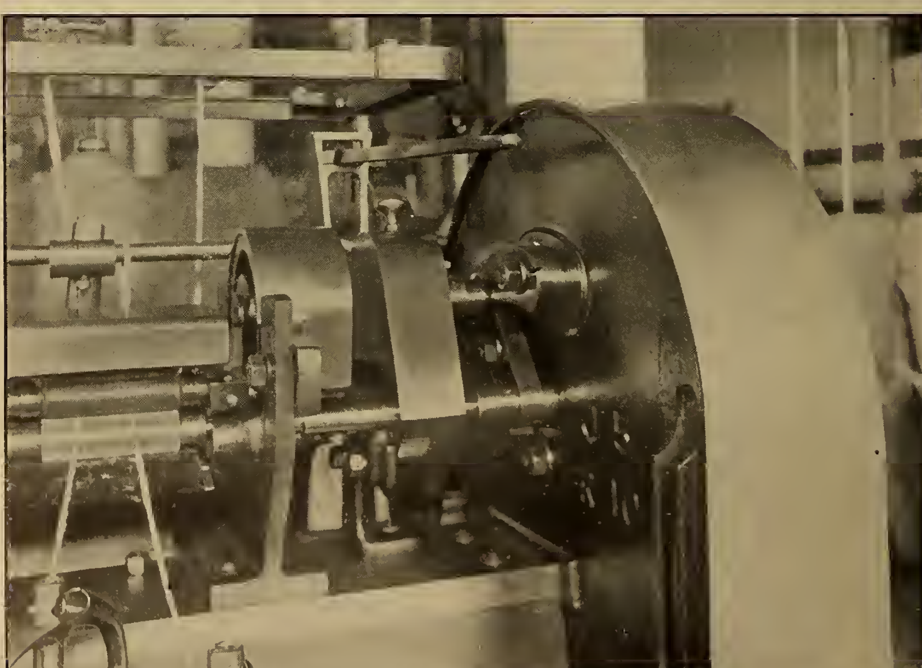


FIG. 22.—GUARDS OVER DRAFT PINIONS OF SPEED FRAMES

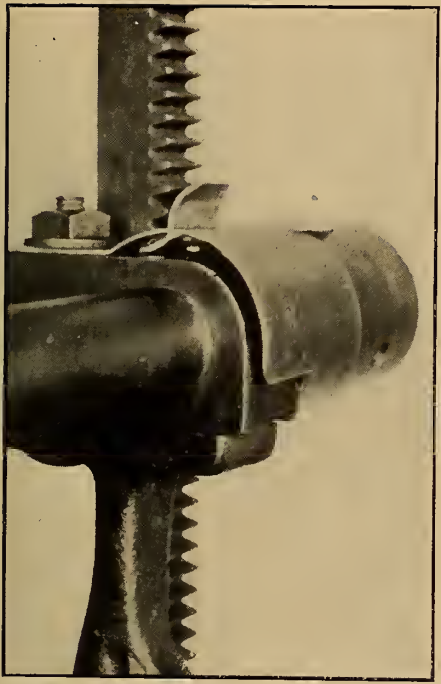


FIG. 23.—GUARD OVER RACK PINION OF SPEED FRAME

the accident roll has been reduced by 92 per cent.

In all speed-frames the bobbin-shaft, with its bevel-wheels, rises and falls simultaneously with the build of the bobbin of yarn. In the slubber this vertical motion is most rapid, owing to the thick sliver-coils being placed on the bobbin at greater intervals; on the rover the vertical motion is slowest, the sliver being finer and coiled closely on the bobbin. The rise and fall is regulated by a series of small pinions geared to vertical racks attached to the bobbin-shaft frame. These pinions revolve slowly; but accumulations of cotton are unsuspectingly removed from them during cleaning operations, Casualties occur chiefly on the slubbing-frame, where the reversal of the pinion is most abrupt. Operatives pick out the "fly" or waste cotton when the lifting rack is near its highest point. Suddenly the rack descends, the pinion reverses, and the unwary finger is trapped. To meet this difficulty, guards are now provided in sheet-steel (Fig. 23).

FIG. 24.—ONE OF LANCASHIRE'S NEW COTTON MILLS AT MIDDLETON

THE RAILWAYS OF BRAZIL

By Lionel Wiener

V.—THE CENTRAL GROUP

THE Central Group is by far the largest of the Brazilian railway systems, comprising, as it does, nearly half of the total mileage.

This group is made up of a number of lines, leading either to Rio or to Santos.

Starting from Rio, the lines run parallel to the coast northward into the State of Espirito Santo, southward into the State of Sao Paulo, and inland to the Sao Francisco river, which is navigable through the whole of the Minas and Bahia states.

Starting from Santos and Sao Paulo, the main lines run west to Corumba, north to Araguay and Catalao, and south towards Parana and the republic of Uruguay.

Between these two systems there is an incomplete network of railways which we will call the Minas Intermediate System.

Of course each of these systems is not confined to the State whose name it bears, but this division is practical for railway purposes, and, in fact, it is lkely to become a real division shortly, as the more important companies are gradually absorbing the smaller ones. This will leave the following railways:

In the Rio division, the Leopoldina Railway; in the Sao Paulo division, three important companies, the Mogyana, Paulista and Brazil railways, besides the Sao Paulo Railway down to Santos.

In between these there will be the Central of Brazil Government Railway and a new system formed of the various Minas lines under government control.

All of these railways are served by but two harbours of any importance: Santos, in the Sao Paulo portion; and Rio in the other.

In both portions long penetration lines are sent out, like tentacles into the wild country beyond, some connecting with the first and others with the second of these harbours.

Thus, from Santos, the Sao Paulo Railway leads to Sao Paulo, beyond which the following connections extend:

1. Itarare and Santa Maria, in the south, can be reached over the Brazil Railway and the Rio Grande Railway, a distance of more than 1,200 miles, this line being nearly completed.

2. The Sorocoabana, now the Brazilian Railway, also leads westward to Salto Grande and Agua Boa, 476 miles from Santos; it is about to be continued to Tibyrica, several hundred miles beyond, at the confluence of the Paranapanema and Parana rivers.

3. The Northwestern Railway leads to Itapura and Corumba, on the Bolivian frontier, a distance of more than 1,200 miles from Santos. This line is open to Itapura, and construction is being continued beyond.

4. Barrettos, in the northeast, near the Rio Grande river, is reached by the main line of the Paulista Railway, a distance of 287 miles from Santos.

5. The main line of the Mogyana Railway leads to Araguay, 670 miles from Santos, and is about to be extended still further, into the State of Goyaz.

From Rio the Central Railway extends:

1. To Formiga and Catalao, through Barra Mansa, by the West

CENTRAL GROUP OF RAILWAYS—EASTERN PORTION

of Minas and the Goyaz Railways, and then on the Araguay river, down which steamboat lines ply to Belem. Of the total distance of 1,009 miles, a little less than one-half is open to traffic, reaching to Bambuhy.

2. The West of Minas Railway reaches to Sitio and Paraopeba, a distance of 603 miles.

3. The main line of the Central of Brazil Railway reaches a distance of 637 miles to Pirapora. Both of these lines reach the Sao Francisco river where it is navigable.

The lines of the Leopoldina Railway running out of Rio are shorted, and include the section from Rio to Saudo, 281 miles long; from Rio to Santa Luisa, 270 miles in length; and from Rio to Victoria, the capital of the State of Espirito Santo, a distance of 375 miles, including a short section still under construction. All these lines lead either to Sao Paulo or to Rio, not only because they are the capitals of States, but because the Serra do Mar is so forbidding that it is nearly impossible

to run down to any other harbour.

Having given a list of the penetration, or inward lines, we will cast a glance at the exportation, or outward lines. These all branch off from a line which, starting from Sao Paulo, runs approximately parallel to the coast. Then crossing the Parahyba river a few miles from Sao Paulo, each line follows the stream through Barra Mansa and Entre Rios to Campos.

The course of the river is curious. Taking its source near the sea, it starts southward towards Sao Paulo. It then curves around the Serra do Mar and follows the land side of the mountains parallel to the coast, running from a long distance to the north, until, in Sao Fidelis, it seems suddenly to make up its mind and rushes into the sea at Sao Joao with such impetuosity that it forms a barrier absolutely impassable to craft of any kind. It is at this point that the railway from Sao Paulo, which has kept to its banks, now on one side and now on the other, finally reaches the coast, after a run of 547 miles.

1. South of Sao Joao, the first line to scale the hills is the one from Nictheroy, opposite Rio, to Mello Barretto, on the Parahyba river. This line is 130 miles long, and until recently it used locomotives on the Fell system, with third rail, on the grades.

2. The Mage and Theresopolis Railway also starts from the bay of Rio, but goes no further than the 21 miles to Theresopolis; this line uses the Riggenbach rack system.

3. From Nictheroy to Entre Rios, by the Leopoldina Railway is a distance of 80 miles, and a rack is required.

4. The Central of Brazil Railway operates a narrow gauge line from Rio to Parahyba do Sul. This line is 104 miles long, and does not use a rack, but the grades are too steep.

5. The broad gauge main line runs from Rio to Barra do Pirahy, a fine piece of engineering 68 miles long.

6. A line was projected fifty years ago from Angra to Barra Mansa, but only 27 out of the total of 68 miles have been built, and the road never completed.

7. The Santos and Sao Paulo Railway is a remarkable, broad gauge cable railway, 54 miles long up the Serra.

Four other lines are projected, down to Santos, all intended to use artificial adhesion. Beyond these the Parana Railway scales the hills, this being the most noteworthy of the number.

Still further south, lines have been started to Sao Francisco, Itajahy, and Laguna, but none of these has got beyond the foot of the Serra.

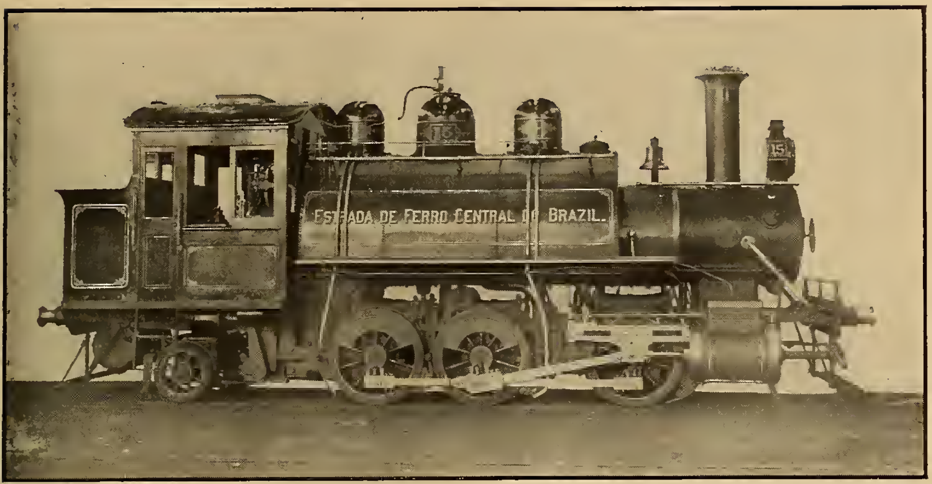
Thus we have, along one thousand miles of coast, only seven lines in all; and of these two use rack rail, one a safety third rail, one employs cable traction, and one has grades which are too steep.

THE CENTRAL RAILWAY OF BRAZIL

The Central Railway of Brazil is one of the oldest railways of the republic. Starting from Rio, it scales the Serro do Mar, includes a penetration line, and reaches Barra do Pirahy, beyond the hills. From Barra there is an easterly extension along the banks of the Parahyba to Porto Novo da Cunha, whence it is continued, by the Leopoldina Railway and a westerly one, up the river to Sao Paulo. The main trunk line continues nearly due north, right away to the Sao Francisco river, which it reaches at Pirapora, beyond which transport by river steamers continues for an unbroken stretch of nearly a thousand miles.

The Central Railway possesses an interest all its own, not only because it is one of the most important railroads of Brazil, but also because it has literally grown all these years, owing to the tenacity of a number of railway ministers, who have succeeded each other in far too rapid succession.

The line was originally started by



SIX-COUPLED SWITCHING LOCOMOTIVE FOR THE CENTRAL RAILWAY OF BRAZIL. BALDWIN LOCOMOTIVE COMPANY, 1902

the Dom Pedro Secundo Railway Company inland for a distance of 32 miles from Rio. It was opened to traffic in 1858, with an equipment of 9 locomotives, 40 carriages, and 100 wagons; the track being constructed on the Barlow-Brunel broad-gauge system, of 5 feet 3 inches, its present gauge. It is doubtful whether it was wise to build such a broad gauge line across such a hilly district, and there is little doubt that the expenditure involved in negotiating the Serro do Mar led to the slow progress of the company, and also its ultimate discomfiture, since the crossing the range of hills was particularly difficult. In the short stretch of 29 miles between Belem and Barra do Pirahy there are no fewer than 16 tunnels, one of which is nearly 1½ miles long.

The difference in level between the tunnel and Belem is 1,080 feet. The large tunnel required six years in construction, and during that period a temporary line was laid over the hill, a plan which had previously been used on the Baltimore & Ohio Railroad by Mr. Latrobe, and since in other places in the United States. The steepest grade on the Dom Pedro II temporary line was 1 in 18, and the trains were hauled by ordinary adhesion locomotives.

After a lapse of eight years the stretch of 68 miles from Rio to Barra do Pirahy was opened, there being seven sections in this portion. From here to Pirapora, on the Sao Francisco river, the full length of the line was completed only by January, 1910, this adding 34 more sections, bringing the total up to 41 sections, a distance of 574 miles, in a period of fifty years. During this time the original company, which had become financially embarrassed, had disappeared, and the government of the empire had assumed control of the property, extending the line northward, as we have seen, through Minas; besides east and west, up and down the Parahyba valley. The westward branch ran to the frontier of the State of Rio, where it connected with the Rio and Sao Paulo Railway, a metre-gauge line, running into Sao Paulo. This line has since been bought, and altered to the gauge of 5 feet 3 inches. The northern extension was built to the metre gauge beyond Lafayette, about half way, but it is gradually being converted to the broad gauge.

In 1889, when the Republic was

established, the name was changed from the Dom Pedro II Railway to the Central Railway of Brazil. The railway comprises, besides the above, a branch from Rio to Santa Cruz and Matadouro; two branches starting from Barra Mansa north and south, each about 30 miles long; and parts of the West of Minas trunk line, which should have started from Angra, on the coast. There was too great an interval between these sections and the rest of the West of Minas Railway for them to be worked at any profit, and upon taking over the West of Minas Railway, the government incorporated them with the Central Railway.

Bello Horizonto, the capital of the State of Minas, is connected by a short branch line to the main north line, and another branch starts from nearly the same point eastward. It was begun by the State of Minas, and known as the Santa Anna de Ferros Railway, which point it will reach in due time. This branch is very important, because it is a penetration line which will link up the South of Bahia Railway with the Central Railway, and connect with all the centre of Minas, including the rich Diamantina and Pechana districts. In addition, the Bello Horizonto connection with West of Minas is the natural extension of this line further west, linking it with the northern railway of the State of Sao Paulo.

Another interesting line is the one from Rio through Estiva to Parahyba do Sul, called the Linha Auxiliar, formerly the Brazil Improvements Railway Company. This follows the main line of the Central Railway from Rio to Belem. Much traffic comes down from the north, from Ouro, Preto, and Marianna, where the Ouro-Preto branch is about to be extended, and to the Lafayette manganese districts, also to Entre Rios, where the Porto Nevo traffic joins it. The trains running round to Barra Mansa formerly met the

PASSENGER CAR BUILT FOR THE CENTRAL RAILWAY OF BRAZIL BY LES ATELIERS METALLURGIQUES, BRUSSELS

important Sao Paulo traffic, all of it continuing down to Rio. This stretch was therefore much congested, being single track except near Rio, where there are two, three and four tracks. The government put off widening the road because of the expense. The reason for the Central Railway purchasing the Auxiliar line was that most of the traffic of Entre Rios could be directed that way, besides being shorter. The Auxiliar line is built to the metre gauge, but the broad-gauge portion between Parahyba and Entre Rios has been laid with a third rail, permitting through trains to be run from Rio to Entre Rios. The wagons are of the same capacity as those of the broad-gauge, 30 tons. The gradients are steeper than on the main line, but there are fewer stations, and the route is essentially a through one.

The following data will enable the two routes to be compared:

COMMON LINE—ENTRE RIOS—PARAHYBA.

Length	6	miles.
Stations	1	
Curves	600	ft. rad
Gradients	1 in 55	
Quickest train	⅓	hour.

PARAHYBA TO RIO VIA BARRA-PIRAHY LINE.

Length	117	miles.
Stations	54	
Curves	600	ft. rad
Gradients	1 in 55	
Quickest train	4¾	hours.

PARAHYBA TO RIO VIA AUXILIAR LINE

Length	104	miles.
Stations	17	
Curves	330	ft. rad.
Gradients	1 in 36	
Quickest train	8½	hours.

In 1908 the third rail was continued from Entre Rios to Porto Novo, where it joins the Leopoldina Railway.

The Auxiliar line, notwithstanding all that is argued in its favour, is not the useful adjunct which it should be, and should the Rio extension be built it would be useful to the Leopoldina Railway or to the West of Minas Railway.

Apart from the Leopoldina Railway Company, none of the other railways, except those of Sao Paulo, has a well defined and proper zone. This explains why so many of them keep on changing hands, various combinations being tried only to be abandoned. Both the rivalry and competition of the several companies, as well as the influence of politics, contribute to the general instability.

In January, 1909, the system was made up as follows:

Line.	Date of Opening.	Miles.	Gauge.
Main—Center Line, Rio to Lafayette	1858–1883	452.3	Broad.
		10.3	Mixed.
Lafayette to Miguel Burnier	1886–1887	35.6	Mixed.
Miguel Burnier to Pirapora	1887–1910	511.0	Metre.
Gamboa Branch to Maritima, Rio	1880	0.6	Broad.
Santa Cruz Branch to Matadouro	1878–1884	35.0	Broad.
Santa Cruz Branch on to Itaguahy	Building.	.....	Broad.
Paracamby Branch	1861	3.0	Broad.
Ouro-Preto Branch	1888	3.8	Mixed.
Ouro-Preto Branch	1888	22.8	Metre.
Bello-Horizonto Branch	1895	8.8	Metre.
S. Anna de Ferros Branch to Caethe	1908	10.1	Metre.
S. Anna de Ferros Branch onward	Building.	.....	.....
Porto Branch from Entre Rios	1867–1871	40.9	Mixed.
Auxiliar Line, Rio Parahyba	1898	104.7	Metre.
Sao Paulo Line, from Barra de Pirahy	1871–1875	242.6	Broad.
Cedro Branch, from Barra Mansa	1897	32.5	Metre.
Rio Claro Branch, from Barra Mansa	1897	26.8	Metre.
Penha Branch, from Sao Paulo	1875	.....	Broad

Of the total 1,159 miles, 40 per cent., or 555 miles, are broad gauge; 46 per cent., or 531 miles, are metre gauge, and 6 per cent., or 72.4 miles, are mixed gauge.

The system is single track throughout, with the exception of a portion of the main line leading out of Rio. There are three tracks from the Rio central station to Madeira, about 10 miles out, and two tracks on the Belem, 28 miles further. There is a large suburban traffic on this section, which is much congested in the morning and evening, notwithstanding a loop for turning the trains at Belem, and a relief service from the Rio Initial Station to Belem, by the Auxiliar line. Taking the bull by the horns, the railway authorities have decided to introduce electric traction on the suburban section, and perhaps on the entire Serra line.

Under the present conditions the suburban traffic is continuous day and night. The utilization of the trains, which in 1907 was 40.42 per cent of the seats offered, reached

LOCOMOTIVE FOR METRE GAUGE, 4-8-0 TYPE, BUILT FOR THE CENTRAL RAILWAY OF BRAZIL BY THE AMERICAN LOCOMOTIVE COMPANY

64.94 per cent. in 1908, and is still increasing. As the flow of passengers is irregular, this means that between five and eleven o'clock in the morning on the up trains, and between three and eight o'clock on the down trains, fully half the passengers are obliged to stand.

The new station at Rio is to have ten lines, besides an up-and-down line, connected by a 131-foot loop, to be used exclusively by surburban trains, this loop, which forms a complete circle, thus being useful for shunting purpose. There is no doubt that this will be the quickest way to deal with the expected traffic.

The extraordinary rapid growth of the passenger traffic in late years is shown by the following figures, which refer to suburban passengers only:

1903	13,423,779
1904	15,388,061
1905	16,970,034
1906	17,858,385
1907	18,766 689
1908	20,128,387

The total number of other passengers in 1908 was only 1,876,588, or less than one-tenth of the number of suburban passengers. This is doubtless partly due to the low rates for suburban passengers, and to the high cost of houses in Rio.

Monthly season-tickets are issued at cheap fares; for instance, to Paracamby, a distance of 44 miles, or to Mendes, 58 miles, at £3 15s.; and to Desengado, 83 miles, and to Bueno, 78 miles, for £7 10s.

The cost of kilometrical books is as follows:

3,000 kilometres (1,864 miles)	$102	(£ 6 7s. 5d)
6,000 kilometres (3,728 miles)	180	(11 5s.)
9,000 kilometres (5,592 miles)	248	(15 10s.)
12,000 kilometres (7,456 miles)	300	(18 15s.)

These rates are about one-half of those charged by the Leopoldina Company.

The Central Railway is not a system, properly so-called; it is made up of two perpendicular lines, Rio to the North, Sao Paulo to the East, where the Leopoldina acts as a boundary. A number of unimportant branches, belonging to small private companies, join it at convenient places. These act as feeders, but are worked at too high a cost, as might easily have been foreseen. An amalgamation with the Central Railway is desirable, and has, in fact, been commenced. Thus, of the nine branches of the Central Railway, five, the Bello Horizonto, the S. Anna de Ferros, the Sao Paulo, the Cedro, and the Barra Mansa, did not originally belong to it, and have been taken over only recently.

There are still nine short branches of the system, aggregating 289 miles, which should be absorbed, namely:

1. The Rio Doce Railway, 108 miles long, running from Palmyra, on the Central Railway, to Livramento, and being extended further.

2. The Juiz de Fora and Rio Novo, recently taken up by the New Juiz de Fora Railway Company, a short

COMBINATION CAR BY LES ATELIERS METALLURGIQUES, BRUSSELS

connection, 38 miles long, between the northern extension of the Central Railway and the Leopoldina system.

3. The Uniao Valenciana Railway, a line 39 miles long, running north from Desengano, on the Sao Paulo extension, to Rio Preto, on the frontier of Minas. This line is built to the 3 feet 8 inch gauge.

4. The Rio das Flores Railway, 38 miles in length, which connects Parahybuna, on the Sao Paulo branch, with Commercio, a station on the

RAILWAY TRUCK BY LES ATELIERS METALLURGIQUES, BRUSSELS

DECAPOD LOCOMOTIVE, BUILT FOR THE CENTRAL RAILWAY OF BRAZIL IN 1885

The first locomotive of this type built by the Baldwin Locomotive Works.

northern extension. The last five miles of this line, from Tres Ilhas to Parahybuna, and temporarily worked with horse traction.

5. The Vassoura Railway, a little line only four miles long and 23½-inch gauge, reaching the town of Vassoura, just off the Sao Paulo branch.

6. The Bananal Railway, 18 miles long, from Barra Mansa. This line has had much trouble to maintain an existence. It became so badly involved in debt that it was seized by the creditors and closed for several years. It is open again, but its prospects are so poor that it has been relieved from the usual fiscal tax on all railways, and it is worked now with a small yearly deficit.

7. The Rezende and Bocaina Railway. This is but the first part of the Rozende and Areal Railway, a stunted line 27 miles long.

8. The Lorena and Coronel Barreiros Railway, a line 12½ miles long, is operated by the war department, to connect the Barreiros powder-magazine with the Sao Paulo extension.

9. The Taubate and Tremembe, the Local Interests Railway, is a short line, 24 inches gauge, and 7 miles long, on the Sao Paulo extension to the river Parahyba, a little to the north. A project has been standing for a long time to lengthen this line southward to Ampare, a rather important harbour on the coast, at present without railway connections.

In like manner the Rio Claro branch of the Central Railway is destined to reach Angra, on the coast, where it is to be joined by the Matadoura branch from Rio.

The Rio do Ouro Railway has purposely been left until the last. This is also a government road, which has been kept separate from the Central Railway, which it follows closely from Rio northward, forking into two branches, at the points of which lie Rio do Ouro and Tinga. Including nine small branches, it is only 71 miles long, and is used principally in connection with the water supplies of Rio. In 1906 it was operated at a cost of 184.65 per cent of the gross receipts, and in 1907, at 120 per cent. This is rather better than usual, and in 1897 it reached as high as 551.4 per cent. This line was opened in 1883, and has always been worked at a loss, except in 1889, at 76 per cent., and in 1890 at 97 per cent. The rolling stock comprises 16 locomotives, 16 coaches, and 90 wagons. There is little chance of such a line being of any value to the Central Railway, or to anybody else.

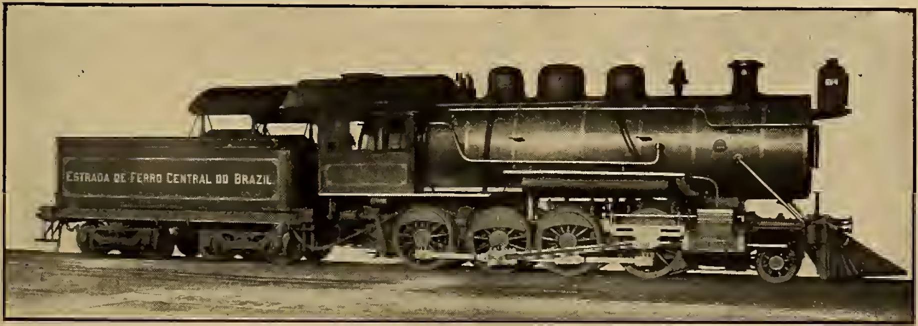
The Central Railway itself is not a financial success; it is worked at a cost of 97 to 98 per cent. of the earnings. This, however, is not so bad

MALLET LOCOMOTIVE BUILT FOR THE CENTRAL RAILWAY OF BRAZIL BY THE AMERICAN LOCOMOTIVE COMPANY

as it seems. The State contends that it does not want the road as a source of revenue, but rather to train its engineers and form a basis of comparison for other roads.

Offers to lease the system have frequently been made, even as far back as 1869; and again in 1883, 1895, 1898, and 1903, but none of these offers has come to anything. The last time the matter was considered the leasing principle was accepted by parliament, on the condition that the lessee should pay 10 per cent of the gross earnings and complete within ten years all the works then projected or in hand. These latter included the construction of the fourth surburban track, the conversion of the Sao Paulo line to the broad gauge, the consolidation of all bridges to Entre Rios, the construction of a second track from Belem to Barra do Pirahy, and the building of the extension to Pirapora and the new Rio station. The lease was to run for fifteen years. These terms were, of course, far too drastic, especially when it is considered that the staff of the railway, under the government operation, was more than 12,000, and it was forbidden to discharge the useless three-fourths of them, so it is no wonder that the proposition was declined. It is interesting, however, to note that for the first time the principle of leasing was considered in the House, instead of adhering positively to the "patriotism of government railway enterprise."

It would certainly be a good thing to lease the system, which is worked with most of the drawbacks of State railways, and only one of the advantages, that of cutting down the rates as soon as there is a small margin of profit.



CONSOLIDATION LOCOMOTIVE OF 1905. BALDWIN LOCOMOTIVE WORKS.

The following are the new rates, which have been in force since 1908, converted into the equivalent in pence:

FREIGHT AND PASSENGER RATES ON THE CENTRAL RAILWAY OF BRAZIL

PASSENGER FARES.	From 1 to 156	From 157 to 312	From 313 to 468	469 and Over.	Minimum.
Express—1st single	1.93	1.45	0.87	0.63	6d.
1st return	2.90	2.17	1.30	0.94	15d.
2d single	1.20	0.72	0.39	0.24	4.5d.
2d return	1.81	1.09	0.58	0.36	7.5d.
Slow train—1st single	1.45	1.11	0.72	0.48	4.5d.
1st return	2.17	1.67	1.09	0.72	7.5d.
2d single	0.87	0.63	0.24	0.14	3d.
2d return	1.30	0.94	0.36	0.21	7.5d.
LUGGAGE AND MERCHANDISE. Per Ton.	From 1 to 62	From 63 to 187	From 188 to 375	376 and Over.	Minimum.
Express—Parcels	39.71	28.85	19.20	14.48	4.5d.
Luggage	25.22	19.20	14.48	9.16	3d.
Slow train—Parcels	18.10	14 48	9.65	7.24	4.5d.
Luggage	15.69	12.07	7.24	4.82	3d.
ANIMALS.					
Per head—Horses	1.81	1.69	1.57	1.45	15d.
Oxen	0.96	0.84	0.72	0.60	15d.
Sheep, pigs	0.23	0.21	0.14	0.07	6d.
Per wagon—Horses, oxen	7.68	5.76	3.86	3.14	18.s 9d.
Sheep, pigs	14.50	9.60	4.80	3.62	18.s 9d.
Coffee	6.76	3.14	1.57	1.45	
	4.59	2.17	1.09	0.97	22.5d

Lime pays 2*s.* per 9-ton wagon and 62 miles, plus a fixed charge of 4*s.* 10*d.* Manganese ore pays $8 up to 315 miles, with the exchange at 6 to 8 pence per milreis ($); with a weaker exchange these rates are increasd at 1 milreis per penny and decreased at ½ milreis per penny at a better exchange, up to 1*s.* per milreis. For and above this exchange the charge is 6 milreis. Beyond 315 miles, manganese pays 0.019 milreis per ton-mile. The mobility of the charge with the exchange is curious, but it does not make much complication.

The price of coffee carriage depends upon the coffee market. The Sao Paulo Coffee Syndicate fixes the price and the above rates are reduced by 10 per cent. per each milreis fall beneath the standard price of 7 milreis per arroba (33 pounds).

Specially reduced fares are provided for the suburban trains. From Rio Central to D. Clara, 110 miles, or to Deodro, 15 miles, and from Sao Paulo to Penha, tickets are issued at 4½*d.*, first class, and 3*d.*, second class, with return tickets at 7½*d.* and 4½*d.* These fares apply strictly to the suburban trains, and other rates are in force on the short distance trains.

In computing these fares the Central Railway is obliged to enter into considerations which would not influence a private company. The development of the country served by a railway is always a matter of the utmost importance, but in this case the opening up of new industries, whether on the system or not, is a consideration which weighs in establishing the tariffs.

The lines are laid with heavy rails, usually on wooden sleepers, placed 31 inches from centre to centre. There are two types of iron sleepers for each gauge. On lines laid to the metre gauge they weigh 53 to 79 pounds each; on broad gauge lines the weights are 121 and 124 pounds respectively.

There are four types of rails on the metre-gauge roads, weighing 42, 48, 52, and 55 pounds per yard, and four types on the broad-gauge roads as well. The older rails, called the A-type, were in lengths of 25 or 21 feet, and weighed 68 pounds per yard. The B-type weighed 62 pounds, and was in three lengths, 24, 28, and 30 feet. The C-tpye, a heavier rail, weighs 84 pounds, and is used in lengths of 27, 30, and 35 feet.

The increase in weights of rolling

stock and in traffic, however, has demanded still heavier rails, and the company is now installing a rail of 102 pounds per yard.

Wooden sleepers are considerably cheaper than iron ones, especially as first-class wood is coomon and not costly, whereas the freight charge on iron sleepres forms a heavy handicap. On the broad-gauge lines the sleepers are 8 feet 8 inches to 9 feet long, 8 to 10 inches wide, and 6 inches thick; on the metre-gauge roads the dimensions are 6 feet to 6 feet 4 inches long, 7 to 8 inches wide, and 5 to 5½ inches deep. These sleepers are creosoted, absorbing about 1½ gallons under a pressure of 73 pounds. Experience shows that this operation extends the life of a sleeper from 9 to 15 years, the cost being raised from 5*s.* to 5*s.* 2½*d.* only. The choice of the most suitable wood has been an important matter. The various species have been grouped into first and second class, as follows:

First-class woods.: The arceira do sertao wood is the very best; then come the Brazil tree, the black or white cannella, black or white guarauma, the ipé (one of the heaviest woods, with a specific gravity of 1.156), the coloured jacacranda, the black or red oleo tree, the pink peroba, the puina, the red sapucaia, the sobrazil tree, the yellow sucupira, tupinhoan, ubatan, urucurana, and the tinted cannella.

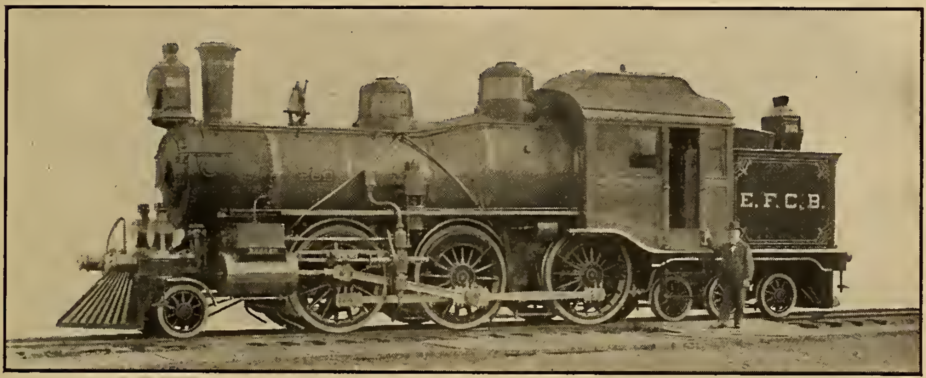
Second-class woods: The angelin, the angice, the yellow arapocu, pink arariba, yellow cannella, cangerana, capehano, garapa, grossahy, guarabu, iperiba, jatoba, mangalo, assaranduba, oiti, oelo, jatahy, yellow peroba, red sapucahy, and last of all, the turuman.

Of the above, the black and red oleo wood last 12 years, and the coloured jacacaranda, the piuna, the sobrazil, the yellow and black sucupira, ubatan, and urucurana, about 11 years.

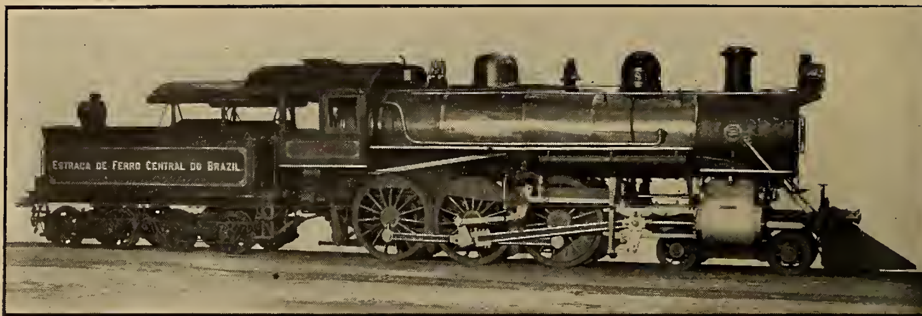
The best and hardest wood is the arceira, whose specific gravity is 1.219, and its strength 14,370 pounds per square inch. The poorest is the yellow cannella, with a specific gravity of 0.402, and a strength of only 10,987 pounds per square inch.

Tunnels and bridges are frequent on the Central Railway. The five bridges over the Parahyba are of 284 feet and 541 feet, both near Serraria; of 538 feet, at Guararema; of 445 feet, at Anta; and of 538 feet in length, near Sapucaia. The Retiro bridge, on the northern line, is on a curve, and also on a grade of 1 in 80, and is 356 feet long.

Stone ballast is used everywhere, as it has been found most economical,



FORNEY TYPE LOCOMOTIVE, BUILT FOR THE CENTRAL RAILWAY OF BRAZIL BY THE AMERICAN LOCOMOTIVE COMPANY



BALANCED COMPOUND TEN-WHEELED PASSENGER LOCOMOTIVE, BUILT BY THE BALDWIN LOCOMOTIVE WORKS FOR THE CENTRAL RAILWAY OF BRAZIL

notwithstanding the heavy original outlay; nearly one-half the system, 449 miles out of the 1,102 miles being already so ballasted. Gradients on the broad-gauge lines are limited to 1:55, and the curves to a radius of 597 feet. On the metre-gauge lines the steepest grades are 1:50 on the main lines, and 1:33 on the branches, with a radius for curves never less than 330 feet. The whole system comprises 36 per cent. of level lines and 55 per cent. of alignments, this percentage is always quoted for all Brazilian lines, and is really of hardly any use to determine their difficulty.

The rolling stock is good, and is on the American system, including first and second class coaches, sleepers, baggage and postal cars.

On January 1, 1909, the company owned:

	Broad Gauge	Metre Gauge	Total.
Coaches:			
Special	6	16	22
Passenger and sleeper	333	98	431
Vans	44	16	60
Wagons:			
Animal	290	57	347
Open	844	245	1,089
Closed	1,134	252	1,386
Special	28	12	40
Locomotives	244	93	337

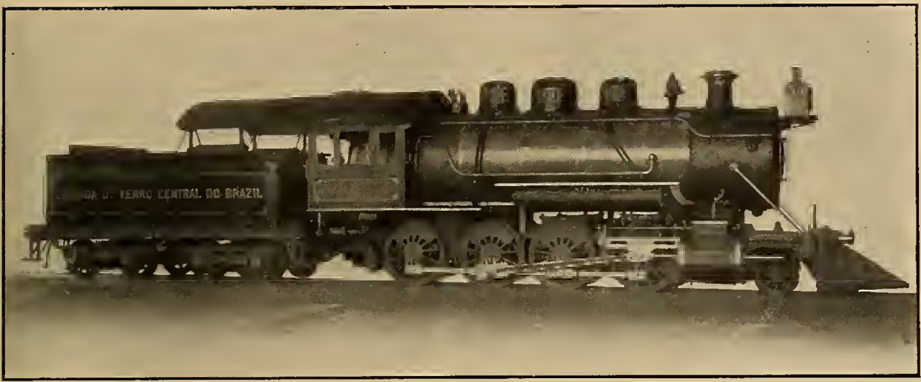
About one-half the carriages have been made in Brazil, and the balance, with the exception of three English, and 135 Belgian, are all of American make. Of the broad-gauge sleeping cars, 22 out of the 27 are of American type, without partitions, and the berths arranged arranged lengthwise along the sides, the usual car containing 20 beds. The five others have separate compartments, and are provided with 12 beds. The charge for a lower berth is 25*s.*, and for an upper berth 17*s.*

Most of the freight cars on the broad-gauge lines carry 20 tons, and weigh 12½ tons.

Ore is carried in 200 30-ton, and 35 45-ton waggons, of 15 and 19 tons tare load respectively. There are 96 tubular wagons for coal, their weight being 12 tons and their capacity 30 tons, so that the useful load is in the same proportion as with the 45-ton manganese ore wagons.

These large capacity wagons have been so useful that the Central Railway has ordered some for the metre-gauge lines, these being 25-ton waggons, weighing 9 tons only, giving a dead load of only 27 per cent.; also some of 40 tons, with only 17 per cent. of dead weight, these latter ranking among the largest wagons for the metre gauge on record.

Practically all the locomotives equipment has been supplied from America, a portion by the Baldwin Locomotive Works, and the remainder by the American Locomotice Company. This locomotive equipment is distinctly American, and has always been well up to date, embodying many noticeable features. The first steel tires used by the Baldwin Locomotive Works were placed on the first locomotives ordered for the Dom Pedro II Railway in 1862, and as none were made at that time

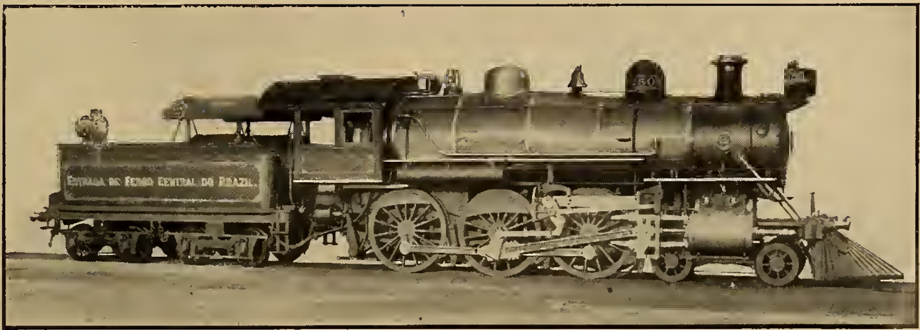


CONSOLIDATION TYPE LOCOMOTIVE, WITH SMOKE-BOX SUPERHEATER, BUILT BY THE BALDWIN LOCOMOTIVE WORKS FOR THE CENTRAL RAILWAY OF BRAZIL, VTJG

in America, they had to be imported. These were made with a shoulder at one edge of the internal periphery, and were shrunk on the wheel centres.

In 1885 the first locomotive of the so-called "Decapod" type, having five pairs of driving wheels connected, and a leading truck, was shipped to the Dom Pedro II Railway. This was, at the time, the most powerful and heaviest locomotive turned out by the Baldwin Locomotive Works. The cylinders were 22 inches stroke by 26 inches diameter, the driving wheels 45 inches in diameter, and the wheel-base 17 feet. The second and third pairs of wheels were not flanged, and the fourth pair was given ¼-inch more play on the rails than the adjacent one. This practically reduced the wheel base to 12 feet 8 inches, and enabled the locomotive to pass easily curves of 500 feet radius, the rails being spread one-half inch wider than the normal gauge. The weight of the engine, in working order, was 141,000 pounds, of which 126,000 pounds were carried on the drivers.

Recently the types of locomotives have been reduced to a few standard kinds. For passenger trains, the American 4-4-0 locomotive, of 1897, and the more powerful 4-6-0 type of 1902 and of 1907, are used. For freight trains the 1897 and 1907 consolidation locomotives (2-8-0) and the 1905 Mallet locomotives (0-6-6-0) are employed; while for shunting, the double-ender switch locomotive of 1902 seems to be the standard. Mogul engines (2-6-0) are used indifferently for passenger and



TEN-WHEEL PASSENGER LOCOMOTIVE, WITH SCHMIDT FIRE-TUBE SUPERHEATER. BALDWIN LOCOMOTIVE WORKS, 1907

freight service, and an almost unlimited variety of engine seems to be at work.

Of the ten-wheel engines, one-half are balanced compound engines, with the high-pressure cylinders driving the front axle and the low-pressure cylinders, outside the frames, connected with the second axle; the cranks on the same side of the locomotive being 180 degrees apart.

The other half of the engines are of the single-expansion type, equipped with Vauclain superheaters. Both types have 68-inch drivers; the latter has cylinders 19 by 26 inches; the former 16 inches diameter by 26 inches stroke for the high-pressure cylinders, and 26 inches by 26 inches for the low-pressure.

The 1902 type carries a boiler pressure of 180 pounds, and has 268 tubes, 2 inches in diameter, and 13 ft. 2¾ inches long, giving 1,840 square feet of heating surface. These engines weigh 135,000 pounds in working order, of which 103,000 pounds are on the drivers.

The balanced compound engines have four tubes more of the same diameter, but a little longer (16 ft. 1 in.) and carry 200 pounds boiler pressure. The total heating surface is 2,426 square feet, of which 2,290 are furnished by the tubes, and 135 by the fire-box. The grate area is increased to 30 square feet, and the total wheel-base lengthened, owing to the longer boiler, being 25 ft. 9 in., as against 22 ft. 8 in. in the simple engines. These engines weigh 167,640 pounds, of which 118,630 pounds are on the driving wheels. The tender carries 6,355 tons of coal and 11,360 gallons of water.

The principal difference between the 1897 and the 1905 types of consolidation locomotives is that the latter engines are provided with Vauclain superheaters.

The Central Railway Company purchased a number of engines from the Brooks Works of the American Locomotive Company in 1894. These were principally eight-wheel coupled goods locomotives of the Mastodon type, besides a number of locomotives of the Forney type for the suburban trains, these trains being made up of four large first class cars of the American type, four second class cars, and two vans. These Forney engines, with a six-wheel bogie under the bunkers, have been turned into Mogul locomotives by the addition of a tender.

In 1897, when further power was required for the Serra trains, the Central Railway bought from the American Locomotive Company the first Mallet locomotives used in Brazil. These engines have proved very satisfactory, doing their work well and being a decided advance on the former equipment for this service.

COMPARATIVE TABLE OF LOCOMOTIVES—CENTRAL RAILWAY OF BRAZIL.

Type	Mallet. 0–6–6–0	Forney. 2–6–6	Mastodon. 4–8–0	American. 4–4–0	Switching. 0–6–0
Builder	Brooks.	Brooks.	Brooks.	Baldwin.	Baldwin.
Date	1907	1894	1894	1897	1902
Cylinders, diameter	17.5 & 28	18 ins.	21 ins.	18 ins.	16 ins.
Cylinders, stroke	26 ins.	24 ins.	26 ins.	24 ins.	22 ins.
Drivers, diameter	50 ins.	62 ins.	54 ins.	67 ins.	44 ins.
Pressure	200 lbs.	170 lbs.	170 lbs.	180 lbs.	160 lbs.
Tubes, number	234	252	248	219	114
Tubes, diameter	2 ins.	2 ins.	$2\frac{1}{4}$ ins.	2 ins.	2 ins.
Tubes, length	18 ft.	11 ft. $\frac{3}{8}$ in.	13 ft. $10\frac{1}{2}$ ins.	11 ft. 6 ins.	12 ft. 2 ins
Wheel base, rigid	9 ft. 9 ins.	14 ft.	15 ft. 6 ins.	8 ft. 6 ins.	9 ft 8 ins.
Wheel base, total	27 ft. 8 ins.	21 ft. 9 ins.	25 ft. 3 ins.	23 ft. $\frac{1}{4}$ in.	17 ft. 2 ins.
Weight, adhesive	206,000 lbs.	110,000 lbs.	142,000 lbs.	63,640 lbs.	62,000 lbs.
Weight, total	206,000 lbs.	126,000 lbs.	170,000 lbs.	99,740 lbs.	92,000 lbs.
Weight, on bogie	......	16,000 lbs.	28,000 lbs.	36,100 lbs.	10,000 lbs.
Weight, tender	98,300 lbs.	72,000 lbs.	82,000 lbs.	60,000 lbs.	.....
Heating surface, firebox	121 sq. ft.	156 sq. ft.	209 sq. ft	137 sq. ft.	86 sq. ft.
Heating surface, tubes	2,195 sq. ft.	1,466 sq. ft.	1,991 sq. ft	1,306 sq. ft.	717 sq. ft.
Heating surface, total	2,316 sq. ft.	1.622 sq. ft.	2,200 sq. ft.	1,443 sq. ft.	803 sq. ft.
Grate	41 sq. ft.	25.7 sq. ft.	30.5 sq. ft.	19.8 sq. ft.	13.6 sq. ft.
Tender, wheels	......	33 ins.	30 ins.	36.5 ins	......
Tender, water	17,000 gals.	13,600 gals.	15,150 gals.	11,356 gals.	4,550 gals.
Tender, coal	8 tons.	5 tons.	7.7 tons.	4.535 tons	2.3 tons.
Tractive power	36,200 lbs.	16,000 lbs.	28,880 lbs.	14,600 lbs.	16.400 lbs.
	5,620 tons.			2,270 tons.	2,570 tons.
Hauls on straight level	5,620 tons.	2.470 tons.	......	......	......

The following table gives a comparison of the various types of locomotives used on the Central lines:—

The average mileage of the broad gauge locomotives is 24,836 miles, and of the metre gauge engines 17,146 miles. Several engines have run a much greater mileage; thus No. 207 has a record of 44,519 miles, and No. 127 no less than 44,905 miles, but this is not to be expected as customary on such lines as the Central Railway of Brazil.

The following statistics relate to the operation of locomotives on both gauges during the year:—

Number of engine-miles run	5,786,906	1,418.951
Number of vehicle-miles	80,687,672	12,853,496
Locomotive repairs, per mile	4.57d.	......
Fuel consumption per engine-mile	9.51d.	6.49d.
Lubricants per engine-mile	0.036d.	0.19d.
Lubricants per vehicle-mile	0.0174d.	0.174d.

Passenger traffic has already been referred to in connection with the suburban trains. It may be noted that the sleeping berths produced a revenue of £18,732, and that kilometrical books to the extent of 364,375 miles were delivered. The aggregate number of miles over which passengers were carried was 279,628,129, earning £654,320.

The goods traffic reached 212,358,034 ton-miles, carried on 141,435 trains, about equally divided between the two gauges, 50.36 per cent. being carried on the broad gauge, 43.05 per cent. on the metre gauge, and 6.57 per cent. on the mixed gauge, although a very different kind of traffic is carried on the broad and the metre-gauge lines.

Goods traffic is comparatively less important than on most Brazilian railways, earning approximately only one-half of the gross receipts, this being due to the exceptional nature and situation of the system. The suburban traffic, however, is not the source of revenue generally supposed, contributing but 13.12 per cent. of the earnings, while 22.88 per cent. is provided by other passengers.

The principal articles coming under the head of goods traffic are distributed as follows:—

	Per Cent.
Sugar	1.64
Coffee	7.03
Cereals	2.31
Produce	6.16
Inflammables	2.26
Ore	4.80
Salt	2.25
Manufactured articles	2.98

To which should be added:—

	Per Cent.
Parcels	6.00
Live stock	4.09
Luggage	1.52

It will be observed that no single class of goods predominates, such as sugar in the Northern States, and coffee in the South. The result is a rather poor utilization of the goods wagons, only about 30 per cent.

The average distance traveled by a passenger is 34.9 miles; by an animal, 147.5 miles; by a ton of luggage, 84.3 miles, and by a ton of freight, 151.3 miles. The expenses per ton-mile is 5s. 7.785d., and per vehicle-mile, 5.189d.

The following table shows the percentages of the several items of expenditure on either gauge, and on the system:—

General charges	2.57	1.00	2.05
Traffic expenses	39.06	17.86	32.16
Accounting department	2.76	....	2.42
Locomotive department	24.05	63.34	36.24
Ways and works	31.56	17.80	27.13
	100.00	100.00	100.00

Of the above expenses 68.70 per cent. comes under the head of salaries and 31.30 per cent. under materials.

As a government concern the proportion of non-paying haulage is high. The effective returns form 82.07 per cent. of the total, 2.06 per cent. are "fictive" receipts, and the balance, 15.87 per cent., "service receipts."

REPORTS

By Lucien Jones, M. E.

THERE is one thing common to all branches of engineering. No engineer is exempt, whether he be the most inexperienced assistant in the office, or the engineer-in-charge of some mammoth project involving the expenditure of millions of dollars. There is the everpresent liability of being called upon to make a report to some one about something.

In the case of the "assistant," he is probably given very short notice, and the report required is something of minor importance which he is supposed to know or to be able to become informed about easily and quickly. His report is usually oral, and most often over the telephone.

The report required of the chief engineer, however, is quite a different affair.

He is informed some time in advance as to when he is expected to render an account of the progress of the undertaking, what portions of the work he is to cover, and about how much detail is desired in each case.

There are as many kinds of reports as there are divisions of engineering, and each report may cover only one, or a variety of subjects, and with a greater or less degree of completeness.

ORAL REPORTS

The one thing that determines the value of an oral report is the fact of the information given being exactly that which was requested. Suppose you send for one of your men; tell him to go down to Greene's Department Store and find out the capacity of their large fire pump. Unless he is an extra good man, he is very likely to return after a time with the startling information that "Green's have two large fire pumps. Which one was it that you wanted to know about?" Or that the pumps "are 8 feet long, 6 feet high, and 4 feet wide, and stand in the northeast corner of the engine room, near the elevators." Also that "the engineer has a lot of trouble with those pumps on account of," etc., etc.

If he is a good man, endowed with a goodly lot of common sense, he will return with the information that, "There are two 'Smith and Smythe' pumps, one of 150,000 gallons, and the other of 200,000 gallons capacity." In a case of that kind, he would assume, and rightly, too, that the information furnished was exactly what was required.

On the other hand, if you are sitting at your desk, and hear an unusually loud rumbling and thumping noise down in the shipping department, and send the first man down there to find out what is making the noise, you will probably learn that "they are packing up a lot of stuff to send out."

If you are really interested in knowing what is going on, you will send the other man. He will return and tell you that "Wilkins has twentyy-three men rushing that order of eight thousand cans of tomatoes, 24 cans in a box, for Gardner & Griffiths, Cincinnati, which must be shipped on the New York Central's noon fast freight to hold the order."

So that, not only must the information given be exactly what was requested, but, to be that, it must be full, complete and accurate. It is "up to" the man who makes the report to decide how much, and what

information is desired, and upon his decision rests his value to his employer.

WRITTEN REPORTS

In this discussion of written reports, we will take under consideration the case of the investigation of the performance of some piece of apparatus or machinery to determine whether it fulfils the requirements set forth by the maker or purchaser for its operation.

The first thing for an engineer to consider when he decides to enter upon an investigation of this kind is the theory upon which the design of the machine was founded.

After he has become fully conversant with this theory of design and operation, he is ready to consider the various methods used in testing this particular form of apparatus.

In this age of standardization, there are standard methods of testing nearly all forms of machinery. Purchasers of machinery specify that it shall successfully undergo some test prescribed by engineers of experience, who have found that a test of that kind is sufficient to establish the satisfactory quality of the apparatus.

It is also well to consider other existing methods of testing this form of machine, noting wherein they are faulty and weak, and why they have been discarded for the "Standard Methods."

If the device to be tested is something newly invented or very unusual, for which no standard method of testing is in use, the engineer in charge must devise tests which will be both adequate and conclusive, without being unreasonable or unfair.

The next step to be taken is to decide upon the condition and form in which the data is to be taken and kept. As all data taken during the investigation are to be included in the report, it is well to have it on sheets of paper of the same size as the body of the report. Therefore, the size of the report sheets must be predetermined before any data are taken.

After this has been done the engineer should go over the entire operation from beginning to end, consider every move that is to be made, and decide upon exactly what observations are to be required.

Then blank forms should be made, so complete and thorough that not one new form will have to be made after the test has been started, and that every observation will have been provided for. With this done carefully, there will be no time or observations lost during the test, as it will be necessary simply to set down the observations as taken in the spaces previously laid out for them.

It is also well to note here that under this plan everything will be set down in exactly the place where it is most desired, and no confusion or searching for data can result.

The time of the day at which each observation is made should be noted in a column reserved for it. This will be an important check in case the numbering of the papers should be wrongly done or the sheet should become disarranged by several men working up results together, or in some other way.

During the progress of the test it is better to keep all data sheets in a loose-leaf note book with a stiff cover, and not allow any man to use the leaves loose.

If the data are to be copied by a stenographer or to be worked up by other persons than those taking the record, it is very important that all figures should be carefully made and checked for clearness. This will apply to all rough notes sent to the stenographer. The greater part of the report can not be dictated, as the work is done in a noisy room. All ambiguity should be studiously avoided. Go on the principle that if there is more than one interpretation possible to a figure or clause, the *wrong* one *always* will be written by the typist.

With the data can be included photographs, drawings or sketches of the apparatus used or tested, being

careful to select the view which covers the most important side of the machine to the best advantage.

Where delicate instruments are used they must be calibrated; sometimes frequently during the test, sometimes only before and after the test. This would include scales, gauges, indicators, thermometers, watches, pyromoters, anemometers, etc.

Before the test begins it must be decided (in making up the log sheets) how many observations of each instrument or condition are necessary to obtain a reliable chronicle of the state of affairs throughout. Some will vary considerably and must be observed frequently, while others will remain fairly constant throughout the test and need be observed only occasionally.

On the log sheets columns should be left after some of the observation columns for "differences." By the use of "differences" some operations can be checked as the test proceeds. This applies to such operations as measuring the rate of filling of a tank, measuring with a hook gauge.

Reading No.	Time.	Hook-Gauge Reading, Feet.	Difference.
1	10.30.00	3.642	....
2	10.30.30	4.108	.466
3	10.31.00	4.574	.466
4	10.31.30	5.041	.467
5	10.32.00	5.507	.466
6	10.32.30	5.987	.480
7	10.33.00	6.453	.466
8	10.33.30	6.919	.466

In the example shown the differences are seen to be fairly constant until the sixth reading. The man taking this log, if he sets down his differences as fast as he observes his hook-gauge, cannot fail to notice that something unusual has occurred between 10:32 and 10:32:30, and he will immediately start to discover the trouble.

But if differences are not used it is very unlikely that the change would be noticed until the results are worked up, perhaps a week later and a thousand miles away, and by some one who was not there when the log was made. In a case of this kind there would be no hope of ever determining the cause, and the results might be seriously affected, or the whole test and report thrown out on this account.

In making out the data sheets provision should be made for keeping all runs separate. Have the data for only one run on a sheet, unless the runs be very short, in which case separate them by as large a space as possible. This will greatly assist in avoiding confusion.

All observations and results should be checked and cross-checked to obviate all possibility of error.

We have thus far considered the taking of data and the actual running of the test. Now we shall look at the form of the report itself and what it should contain.

It should, of course, be typewritten, and should have a cover. The size of the cover will be governed by the size of the photographs or blue-prints included in the report.

The first part of the report should state to whom or for whom the report is made, together with the title of the undertaking and a short, complete statement of what was done, and the reason for doing it. For example:

"In compliance with the request of Messrs. Jenkins and Wilde, 308 Main street, Newark, N. J., we have tested one Morgan & Higgins steam turbine, located at the above named address, to determine its steam consumption and mechanical efficiency."

Then should follow a clear, concise description of the method used in conducting the test, together with a short description, when deemed necessary, of apparatus used which is new or unusual.

After that it is sometimes desirable to explain the method of working up the data to get the final results, and the way in which the observations were checked. This will give the person who receives the report an idea as to the care and thoroughness with which the test

was conducted and the amount of reliability to place on the results obtained.

The sketches and photographs before mentioned can be included at this point in the report, followed by blue-prints, drawings, and all log sheets and data taken during the test The conclusion should be the strongest part of the report. It should be remembered that this is probably the only part of the report that is noticed by the promoter or director to whom it is read, and who may not have the technical knowledge to understand the body of the report, but who holds the purse-strings and makes the decision.

It should be a short, complete summary of the results obtained, containing all the information desired, arranged in the best form for use. The conclusion is that part of the report which makes or mars the engineer's reputation, for whatever is stated there is final and stands.

PACKING MACHINERY

By S. Whettal

PACKING machinery to the best advantage and to obtain the lowest railway and freightage charges is an acquirement that is, no doubt, neglected by many traders. It may even be remarked that owing to the manner in which machinery is packed, or left unpacked, influences the price of the rate, and it often transpires that a trader with a knowledge of railway and shipping charges and an idea of the correct method of packing goods is in a position to obtain more benefits and better rates than one who is in ignorance of the methods of economical and safe packing. As an illustration of the different rates, according to how goods are packed, take the following:

Machinery in Parts.	Packed.	Not Packed.
Machinery in cases........	39/4 per ton	45/6 per ton
Machinery in frames......	39/4 per ton	
Dynamos, in cases.........	39/4 per ton	45/6 per ton
Machines, fitted up......	45/6 per ton	53/10 per ton

These instances are only a few out of many, and especially when shipping goods is it essential that care should be taken to ensure that such goods arrive safely at destination and at the same time travel at the carriage or freightage rate which is most advantageous to the owner of the goods. The sender of the goods is, of course, responsible for the packing of the goods, when the traffic is intended for export, and a charge varying from 2 per cent. to 5 per cent is usually made for packing. This amount pays for the great care which has to be exercised in packing and also pays for the value of the empty packages themselves, which are, of course, in the case of export traffic, unreturnable. Some of the packing cases used for carrying machinery abroad are worth as much as five pounds each, so that it is only reasonable that an extra charge should be made for the extra time taken up in packing, and also for the value of the packages. It is essential that every care be used by the sender in packing, as although insurance is often effected this will not, in many instances, repay for the probable loss of a possible repeat order, and although economy may be effected by a careful packer it does not signify that it is better to send a thin packing case on account of its cheapness; rather is it the opposite. Large machines and engines are often sent without a case, and are merely packed around the more fragile parts with a protection of wood, straw rope or old sacking. This is all right when the traffic has not got to travel a very long distance, but when the goods have to travel, say, to the Far East or to the antipodes, then it is better to have cases or crates, the former for preference. It is easy to understand that the goods when properly packed in a case are less likely to get damaged in transit than when sent bare. One reason for this is that a case is more easy to sling on board a vessel than an awkward piece of machinery. Especially is this so if the latter has several projecting parts which are easily liable to be smashed when the goods are being slung on board. Urgent traffic, which has to travel any considerable distance, whether on land or sea, is better packed in a case; not only for better handling but also to secure, as far as possible, that the goods may arrive at destination in good condition. In respect to small machines and engines it is not always needful or necessary to take to pieces, but the contents should be securely fastened into the case to prevent any

shifting about during transit, either bolts or wedges may be used as is deemed most desirable and convenient. Machines or engines intended for export are usually tested and passed before they are handed over to the packer along with a list of the loose articles. This list should, of course, tally with the articles received to pack, and it is as well to see that this is so, and by checking the list so prevent any inconvenience which might otherwise be occasioned at destination. When machines or engines are dismantled all parts should, as far as practicable, be marked with an initial letter or number, and those letters or numbers should tally with those on the blue print, which it is advisable to forward with the machinery, when same has to be reconstructed at ultimate destination. A little care at the onset will prevent many mistakes and disappointments. Good packing may not secure a customer, but it will often retain one. All cases should be clearly stenciled with stencil paint:

This Side Up with Care.

Be Careful when Slinging.

Name or Initial of Consignee and Destination, or Mark.

Customer's Reference Number.

If more than one case—number 1 upward.

Give name of Ship and Dock when practicable.

All bright parts of engines and machines should be smeared with grease to prevent any possible chance of rusting. Loose small parts should be labeled with catalogue number, wrapped round with oiled paper or canvas and packed in small cardboard boxes to go inside of case. It is most important that great care be taken with the labeling part of the transaction, as it is most unwise to cause customer to be confused when the goods are being reconstructed. For machines and engines which weigh under half a ton it is necessary that the wood be an inch thick and of ordinary white deal, for preference. If over this weight, the case will require to be of greater strength and stability and case should be strengthened by corner pieces and battens across the bottom and sides. When the cases are bolted together and the weight is under half a ton it is usually unnecessary to protect the outside corners, as it is not policy to add to the weight more than absolutely necessary.

The railway charges and the shipping charges on machinery are fairly heavy in proportion to the value, and as an instance we may take the following details, which do not include insurance, dock dues or other port charges:

Selling price of machine, %30 net.	
Carriage, inland town to port:	
Machine, weight in case, 12 cwt., at 17/6d. per ton	10/6d.
Distance, 70 miles.	
Freight from English port to America:	
Measurement, weight 54 cubic feet, at 40 cubic feet per ton, = 27 cwt., at 20/-d. per ton	27/0d.
Total per machine	37/6d.

When the machine is dismantled the size of the case is, of course, greatly diminished and in the instance quoted above the measurement weight would be only 20 cubic feet, so that a saving of 17/0*d.* on the sea freight would be made. However, it all depends upon the circumstances and each individual case must be treated on its own merits, as sometimes it is better to dismantle, whilst in others it is much better to send the machine practically complete and erected. If the machine were sent without a case the machine weight would be reduced by about 2 cwt., but the measurement weight would be about the same, therefore the only saving that would occur would be in the transport charges over the railway.

In conclusion it may be said that packing goods to best advantage is a duty that carries a certain amount of responsibility, and it is really important that all traders should exercise great care in the packing and consigning of all goods whether for home or abroad, as the purchaser is usually sensible enough to appreciate good and careful packing.

Current Topics

THE question of fire risk doubtless reaches its maximum in connection with the various "side shows" and amusement portions of great expositions, and hence it is hardly a matter for surprise that this section of the Brussels Exposition, so fully described by Mr. Newman elsewhere in this issue, should have been the centre of the great disaster which befel that undertaking. While it is a matter for congratulation that so many of the buildings, with their priceless contents, escaped destruction by the fire, it is indeed a subject for regret that such great injury was wrought in the British section. Surely there should be a wider separation between the valuable and serious portions of such an exposition and the ephemeral and comparatively unimportant amusement section, a space intervening, which in itself would insure protection from material disaster by fire.

In his paper on methods of laying out cities, published elsewhere in this number, Mr. Barnaby calls attention to the important part which the provision of ample spaces plays in preventing the spread of conflagrations, and the same considerations should prevail to a still greater degree in those temporary cities which spring up around a great exhibition, and in which material of immense value is often exposed to unusual risks.

ONE of the problems often encountered by the engineer or architect in the course of preliminary work lies in the difficulty in obtaining reliable data about apparently simple subjects. This is especially true in matters relating to the handling of numbers of people. What, for instance, is the capacity of a doorway; how many people will it permit to pass safely and comfortably in an hour, and how many can be crowded through it in an emergency? What is the maximum number of people which can be accommodated by a stairway; how many can be accommodated upon a railway platform without interfering with movement; how rapidly can passengers get in and out of an elevator? These seem like simple matters, and yet quantitative answers to them are not easily found, or being found, can be relied on. Yet they enter into the very fundamental features of the plans of great buildings, of railway stations, of department stores. The entrances of many such buildings are placed, not where they will best serve their purpose, but where they fall into the scheme of the façade in the

architect's design. Stairways are made after previous examples which have, as yet, not exhibited any tendency to excessive crowding, and the width of doorways follows precedent to a slavish extent. The flow of people is a matter concerning which far less is definitely known than is determined of the flow of water, steam or gas; and the engineer who would plan a system of hydraulic mains with as little regard for the known laws of movement as appears in the arrangement of passages, stairways, entrance gates, etc., for human molecules, would soon come to grief.

A moderate amount of effort should make reliable information available upon most of these questions. The use of mechanical counting devices at crowded points would soon give information as to the capacity of the places thus observed, and the construction of artificial congestion points for the express purpose of determining precise data need not be either difficult or costly, while the value of the information thus obtained would prove of incalculable value in future design and construction.

IN the movement of people especially does the saying "the more haste the less speed" hold good, and probably the worst examples of congestion known are those which have followed the efforts of an undirected crowd to escape from danger. Panic disasters are, unfortunately, known in all parts of the world, but much less is understood of the great capacity of passengers for people moving in orderly array at moderate speed. The fire-drills, so admirably conducted in many large schoolhouses, are ample evidence of the quickness with which a large building may be emptied of a large number of irresponsible children simply by the strict observance of order and the laws of human flow. The matter is analogous to the handling of material by the belt-conveyor, and the surprise expressed by the layman, when he is told of the large quantity of material which is carried per hour in the apparently insignificant stream passing before him, would be paralleled by the incredulity of most persons upon investigation of the capacity, for instance, of the traveling platform, with its continuous flow at moderate velocity. It is with people as with inanimate matter in many cases, the greatest obstacle to movement lies in friction and in eddy currents, which consume energy without producing useful results, and one of the problems of the modern engineer who is studying municipal possibilities appears in the determination of the actual conditions and of the fundamental data, after whch many troublesome questions would largely settle themselves.

IRA H. WOOLSON, E. M.

A BIOGRAPHICAL SKETCH

IT is an encouraging development in connection with fire-proof construction that such bodies as the Boards of Underwriters in various places are beginning to realize that the prevention of fire losses is an engineering problem. The true way to reduce the fire loss is to educate the public into the fundamental principles of fire-proof building, by the preparation of building codes for the instruction of builders and owners, and by furnishing such engineering advice and counsel as will enable the underwriters to handle questions of construction from the technical point of view.

Probably no one individual has given more attention to this most important question in the United States than the subject of our sketch, Professor Ira H. Woolson, until recently adjunct professor of civil engineering in Columbia University, New York, and since July 1, 1910, consulting engineer to the National Board of Fire Underwriters.

Professor Woolson is a native of Niagara County, New York, and received his preliminary education in the schools of Lockport, N. Y., after which he entered Columbia Universsity, working his way through college in the face of many obstacles and receiving the degree of engineer of mines from the School of Mines in 1885.

After serving for one year on the New Jersey State Geological Survey he returned to Columbia University, where he remained for twenty-four years, of which five were spent in instruction in the department of mining engineering, seventeen in the department of mechanical engineering, and two years in civil engineering.

For twenty years Professor Woolson was in charge of the testing laboratory of the university, a department which he developed from small beginnings until it became one of the best-known research and commercial laboratories in the country. For the past ten years he has made a special study of fire-resisting materials. In 1902 he was appointed official testing engineer for the Bureau of Buildings of New York City, and in the same year he established the Columbia fire testing station as a personal enterprise. Since then he has tested vast quantities of building material of every description, both for structural strength and for fire-resisting properties. Most of the extensive work of the fire-testing station has been in co-operation with the Bureau of Buildings in connection with its careful investigations into fire-proof construction, these including nearly every variety of fire-proof construction in use in the country. The reports of these tests were made with elaborate detail.

Professor Woolson has published a few of these reports, but a large number are still unpublished owing to lack of funds for the purpose.

In 1901 he developed a standard method for testing fire-proofed wood and personally tested for the Bureau of Buildings samples from many millions of feet of lumber treated for use in New York City.

From 1905 to 1907 he conducted extensive research work for the American Society for Testing Materials upon the thermal conductivity of concrete mixtures and the effect of heat upon their strength. The methods and requirements for testing building brick developed by Professor Woolson have been extensively adopted in testing laboratories and cities throughout the country.

Professor Woolson is a member of the American Society of Mechanical Engineers, of the American Society for Testing Materials, of the National Fire Protection Association, and of the National Association of Cement Users.

DR. GISBERT KAPP,

Professor of Electrical Engineering in the University of Birmingham and President of the Institution of Electrical Engineers.

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THE ART OF LAYING OUT CITIES

By F. Bottge

IN nearly every cultured country a movement has been noticeable for about a decade in favour of a somewhat radical transformation of our cities, in accordance with new and up-to-date principles. It is indeed a great problem, for city building does not mean the mere erection of houses or paving of streets; it comprises the laying out of an entire city after a careful plan, taking into account the technical, artistic, social, economical and sanitary elements. Germany has for some years taken a most active part in this movement, although quite remarkable achievements are also reported from other countries. It was in Germany that, for the first time, a public exhibition of city building in its various forms was held, in Dresden, 1903. This summer it was followed by another and larger international exposition, the *Statebau Ausstellung zu Berlin*, 1910. This latter exhibition has attracted great interest, and visitors have flocked to it from all parts of the empire, as well as from Great Britain, France, the United States and Japan. In many cases they came as deputations sent by some authority or government. In addition numerous requests have been made to transfer the Berlin exhibition to other cities, but this, for various reasons, had to be refused, except in the cases of Düsseldorf, Antwerp and London.

The problem of municipal design is especially difficult with large cities. It was the magistrate of the German capital who organized a competition, with valuable prizes, for plans for remodeling and future rebuilding of Berlin. After many of the best architects, artists and municipal experts had worked for more than a year, and their efforts had been examined carefully by the foremost authorities in their respective lines, it was decided to give the public an insight into the important and difficult problem of city construction by placing the best plans and prize-winning designs on exhibition. This unique contest of a remodeled Berlin has been the center of attraction, and its inspection was the more useful as the projects shown can be in a greater or lesser degree applied to other communities as well as in Germany. Such an exposition also shows what has has been achieved in various countries in the numerous departments of city building, and also what remains still to be done. The public will thus not only become interested, but if capable, may assist the experts and authorities in their efforts. Indeed the general interest in this important problem is already noticeable in

THE BUILDINGS OF THE TRAFFIC MUSEUM AT BERLIN

periodical literature, and there are municipal magazines in every cultured country; while in both Great Britain and the United States papers are published dealing exclusively with the laying out of cities, two such papers being published in Germany. It should always be remembered that the Viennese architect, Camillo Sitte, published in 1889 the first large book upon city construction, having made extensive studies in various districts of Continental Europe. Although he made a very convincing appeal, the public and even the city authorities were so indifferent to his ideas that no practical result of his efforts followed. The untiring and unselfish work of a dozen expert writers was needed to break down the wall of ancient and obsolete ideas. Within about a decade the movement has taken foothold and a flood of pamphlets, brochures, magazine articles and books have appeared in nearly all countries. To these must be added the various competitions, of which the above-mentioned is the greatest. In short, the laying out of cities is being conceived in a growing measure as a scientific problem.

The meaning of such competitions is profound. We obtain thus a large amount of material for the preparation of a town for the coming centuries, including a good transit system, the developing of its architectural appearance, improving the conditions for building, its elements, and making it healthful and generally more suitable for living in.

Every large city is surrounded by numerous suburbs, and these are mostly selfish enough to strive for their own extension, against the interests of neighbouring communities and of the main city. The result of such proceedings, of which I could give numerous examples, is an unpleasing picture of a huge area of built-up blocks without any fixed plan. We all should try to break up this mistaken idea, and in the Berlin exhibition the various communities adjoininng the capital are taught

a lesson and given excellent plans, showing how to build up their vacant land to meet the various modern requirements. All such smaller communities should bear in mind that their future is secured only if they no longer go their own ways, but unite themselves with the projects of the large city adjoining them. Then only it is possible to produce a pleasing picture of the whole combination and to provide a good transportation between the suburbs themselves and the central city.

As regards streets, we observe that most of them in Europe are curved and rather narrow. It is true that this form offers an attractive sight, and the thousands of foreigners passing through old German towns are delighted about the picturesque character of them. On the other hand, they are a drawback to a good transit system and to modern sanitation, and a movement is now noticeable to make the thoroughfares straight. No sensible person would of course adopt the plan of some American cities, where the plan looks like a monotonous chessboard, extremely ugly, built by speculators and not by artists. The German plan is to combine the good elements of both systems, making the streets straight and broad; but, in order to meet æsthetic requirements, to interrupt the rows of average houses by some monumental building or small park, square, statue or arch; also by varying the street crossings, making some closer and some wider apart. Consequently we obtain an effective perspective in looking along even such a perfectly straight road. This arrangement opposes no difficulty for sewer construction or any kind of transportation.

Another lesson can be taken from German methods as regards width of streets. In the inner sections of towns, some of which are many centuries old, one naturally finds many narrow streets, but whenever a new

DIAGRAMS SHOWING TRAFFIC OF THE LARGEST CITIES OF THE WORLD

MODEL SHOWING ARRANGEMENT OF THE KONIGSPLATZ AT BERLIN, WITH THE BRANDENBURG GATE AND PARLIAMENT BUILDINGS

street is laid out, ground of sufficient width is purchased by the community as will suffice for the next 100 years, taking into account increase of traffic. This seems for the first years like an extravagance to purchase more property than is immediately needed, but in practice this is not true, for the street is laid out with a width at first required, as well as the sidewalks, while the remaining ground is rented to the houseowners to be utilised for front gardens. This method is required by law, otherwise they, the owners, could not obtain the license for building, and by this

MODEL OF THE KRUPP COLONY AT ESSEN

EXHIBIT OF MODERN WALL FOUNTAINS

method the city administration receives a considerable sum for this apparently waste space. The roads thus look pretty, and the ground is available at any time whenever increase of traffic requires widening of streets. In England and other conservative countries the property is bought of a width sufficient for present needs, and when, several years later, the thoroughfare has to be widened, additional space must be purchased at an excessive cost, as in the meantime the value of property has greatly increased. Many improvements can be made by making a new street in a densely built-up quarter, but this should not be done after the example of the newer Paris boulevards ploughing through the city; they should be adapted to the architectural situations and provide effective perspectives and good outlines. Of course the cutting through of new streets costs enormous sums, but it will always repay, and in this respect American communities have done good work in recent years, spending many millions in this direction. For civic improvements New York has expended $85,000,000 and Chicago, for its beautiful park system alone, $20,000,000. Much can be done in beautifying the banks of a river, when it passes through a town, by providing driveways such as the Thames embankment in London, instead of placing dirty factories along the banks. There should be a strict separation between the business houses, the industrial and residential districts, the former being in the inner city. All these should be surrounded by a green belt of grass and trees, as is in the Austrian capital. However, it is not recommended to make these green areas like a closed geometrical ring, since this would make an extension of the built-up portions difficult and be a hindrance to transportation, but they should surround the town in irregular groups, intersecting the solid district in a pleasant way and allowing extension and transportation.

The green spots within the city

MODEL OF THE CITY OF VIENNA

itself are also important; they are the lungs of the community. Probably the best improvements have in recent years been made by American towns, plans of which occupied a whole room in the Berlin exposition. There were fine plans, sketches and photographs of Chicago, New York, Boston and Washington; showing parks with their swimming and rowing ponds, libraries, drilling halls, playing fields and wading pools for little children, which latter have so much pleased the Berlin magistrate that similar ones will now be built in that city. We were pleased to see the beautiful surroundings in which American colleges are often located; this cannot be effected for those in Europe, as the latter are far older and space is much more scarce than in the new world. To the department of the sanitary side of city planning belongs a movement which was originated in Great Britain and is still there best developed—the garden city. These occupied a whole room in the Berlin show; pretty pictures and plans of Letchworth, Port Sunlight and others being on view. But Germany can also boast of having some very up-to-date garden cities, the oldest ones being the workmen colonies of the famous Krupp Works at Essen. That firm owns nearly the whole town, employing tens of thousands of workmen and officials, for whom not only residences are provided, but also shops, stores, libraries, hotels, restaurants, churches and the like. Some of these colonies are modeled after the English cottage system, some in the form of two- story flats. Everywhere in Germany we observe the intention to dispense with narrow courts and airshafts, of which the worst in any city are in the tenement quarters of New York. In the Berlin exhibition were shown fine examples of large garden courts, obtained by putting the many smaller ones together, these, of course, being intended for more than one building. By this method the unpleasant rear houses and side wings can also be avoided,

and it is possible by these large courts, and by introducing private passages, to have every house facing a thoroughfare. Thus light and air finds ready access to the residences, as well as to industrial localities, and as most of these open spaces are cultivated, there is brought some bit of nature into the stone desert of a town.

Much attention is now paid in progressive countries to transportation, since we have at last learned to see its importance. In the Berlin exposition several rooms were devoted to this department, and many systems were represented: among others the Metropolitan in Paris, the various underground lines of London and the numerous surface and elevated railways of the large American cities, of which an immense model, showing the wonderful subway system of New York, should be mentioned. Diagrams show that ring-railways seldom yield a good profit, but radial lines reaching out to the business centers were preferable; and furthermore that underground lines are permissible only within a city proper, as the immense cost of construction would render them unprofitable beyond the city borders where traffic is smaller.

PROTECTIVE APPLIANCES IN COTTON MILLS

By H. M. Crawford

CONSIDERABLE impetus has been given to the process of ring-spinning by the erection, during recent years, of some of the largest cotton factories in Great Britain devoted entirely to the manufacture of ring-spun yarn. Just to mention a few, we have the Valley Ring Mill (50,000 spindles), Union Ring Mill (46,000), Era Mill (63,600), and Dale Mill (70,000) at Rochdale. Regent Mill (50,000) at Failsworth (Fig. 1.); Cromer Mill (61,000) at Middleton (Fig. 2), and Nile Mill (94,000) at Hollinwood (Fig. 3).

For a long period there was a decided preference for mule-spinning in regard to both weft and twist, and mule-spinning was not by any means confined to finer counts. Manufacturers were naturally cautious at displacing the mule, which had for a century given such uniformly good results, in favour of a type of machine which had presented many difficulties. Yet it was generally conceded that the ring-frame had a prosperous career ahead. Its main principles were as firmly established as cotton spinning itself. The old spinning-wheel of the 18th century (Fig. 4) is an embodiment of its main characteristics. In this machine the bobbin was placed in a horizontal spindle, and while it revolved in response to the motion of the treadle, a "flyer" was put into operation for the purpose of building the thread on the bobbin. All this was perfectly simple. And when Richard Arkwright, long before he attained his great eminence, conceived the idea of

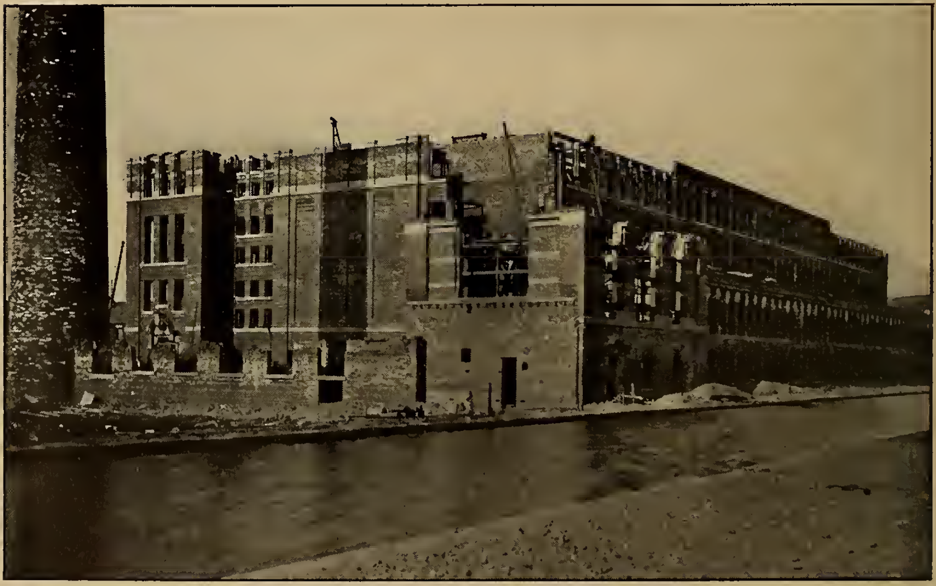


FIG. 1.—REGENT MILL, FAILSWORTH, DURING CONSTRUCTION

FIG. 2.—CROMER MILL, MIDDLETON; IN LARGE SHED ON GROUND FLOOR

his water-frame he based his invention on the "old wheel" with the difference that he erected his bobbins on vertical spindles (Fig. 5). He still retained the flyers, and made his great fortunes at Cromford and Manchester by the aid of this simple adaptation. Then the water-frame had perforce to bow to the trend of the progressive age, and up sprang

FIG. 3.—NILE MILL, HOLLINWOOD

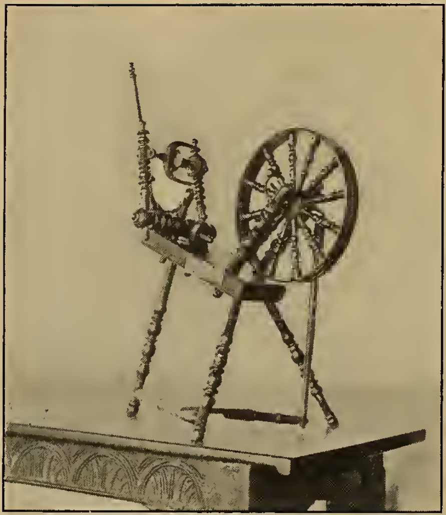


FIG. 4.—EIGHTEENTH-CENTURY SPINNING WHEEL, WITH HORIZONTAL SPINDLE AND FLYER

the throstle frame which captured the North of England as if by storm. Still the throstle retained the flyer and the upright spindle, but instead of a crude array of cog-wheels and straps for turning the draftrollers and spindles, it contained a large revolving tin-cylinder under the machine. This, connected with the wharves of the spindles, would drive both sides of the machine uniformly; and instead of the spindles being driven in sets of four, the new arrangement would operate the whole length of the frame. The throstle was an immense improvement on the best of Arkwright's inventions, and for fifty years at least held its own for coarse counts among the cotton mills of Lancashire and Cheshire. That it had defects—serious ones as the demand of the times proved—was too well known. It could not produce sufficient in quantity; it required much expediture of labour; its wear-and-tear was considerable; its speed was necessarily limited, as any great velocity of the flyers caused these to expand, collide and fracture. Besides, a considerable amount of floor-space was taken up to allow for flyers alone. Obviously these were in the way; and inventive genius was steadily forging ahead in England and in the United States with view to another means of building the cop than by flyers. The ring frame is the result of these experiments, and considering the fact that over a million ring spindles are in operation in England alone, it is evident that ring spinning is now on its forward march to industrial prosperity.

It may be asked "what is the operation of the ring frame as now employed?" The answer can be summarized briefly. Bobbins of loose yarn are received from the roving frames and erected in the double shelves of the creel (Fig. 6). For this purpose a cylindrical wooden skewer is thrust through the core of the bobbin; the top of the skewer perforates the top creel-board, and the base of the skewer rests loosely in a shallow cup of earthenware sunk into the lower creel-board. The bobbin is now free to revolve as the yarn is gently drawn from it by the action of the machine. The yarn is now passed between pairs of draft-rollers which, running at different velocities, slightly attenuate the yarn as it runs through. Each thread is then passed through a spiral wire, also through a small loop or "traveller" of wire (Fig. 7). This loop is free to move round a steel "ring" fixed in the ring-rail which extends from end to end of the machine. The ring-rail rises and falls; and as the thread passes

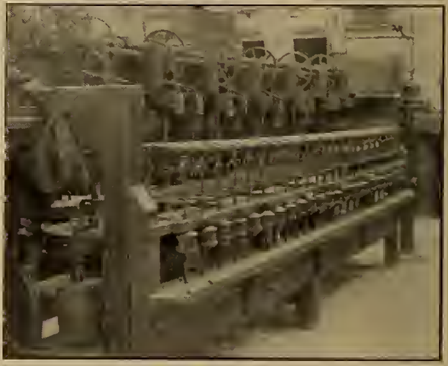


FIG. 5.—ARKWRIGHT'S WATER FRAME. FROM HIS CROMFORD MILL

FIG. 6.—ERECTING BOBBINS IN THE CREEL

through the wire-loop attached to each ring, the ring-rail takes the place of the rising-and-falling bobbins on the old throstle machine. The ring-frame bobbin or cop is on a stationary base. The rising-and-falling ring builds the yarn. The flyer is abrogated entirely. Greater speeds, too, are possible. While the throstle was limited to 5000 revolutions per minute, present-day ring-frames make up to 10,000 revolutions per minute.

These frames are used for producing either twist or weft; whereas the throstle manufactured generally hard twist for warps, hosiery, lace and sewing-cotton. Twist is spun on bobbins; and weft on wooden pirns or paper tubes ready for the shuttles at the loom. The counts spun on ring frames generally range between 20's and 50's, that is, from 20 to 50 hanks of 840 yards to the pound avoirdupois.

When the cops are completed the ring-rail is lowered to its limit; and a few turns of the spindles wind the yarn on the bases of these ready for the new cop. The finished cops are removed or "doffed", fresh pirns are fitted to the spindles and the machine is re-started. Without any piecing whatever the threads immediately

FIG. 7.—THREADING THROUGH WIRE LOOP ON RING RAIL

wind on the new pirns and spinning proceeds anew.

This cycle of operations has, in process of time, disclosed serious risks to the operatives who are almost entirely composed of women and girls. And were it not that strenuous efforts have been made by machinists to eliminate these risks the casualty roll of the ring-frame would have been more alarming. The cog-wheel gearing of the earliest frames was too dangerously exposed, particularly when workers performed some portion of their cleaning with the machines in motion. It frequently happened that workers' fingers were trapped not from cleaning dangerous wheels, but from cleaning stationary parts of the machine in close proximity to such wheels. In moving the cleaning-waste or cloth about, it was suddenly nipped up by the intake of the wheels; and as the operative's hand held the cloth firmly the hand itself was dragged into the wheels before the victim could realize the injury inflicted. The whole hand

FIG. 8.—STARTING A RING FRAME BY HANDLE

has been lost in cases of this character.

The starting-rod, too, was incontinently near to the toothed wheels. In the modern machine this handle is placed outside the frame altogether (Fig. 8) so that the operative's hand is perfectly safe. This is an important factor in the construction of the machine. In ring-rooms which were indifferently lighted workers had to be exceedingly careful in re-starting frames when the handle was in a dark shadow. Doubtless the gearing end (Fig. 9) of the ring-frame is the *locus* of its gravest dangers. Here the toothed wheels are exact and formidable; otherwise they would be unsuited to the exact work they have to perform. These wheel-trains are concerned with the efficiency of the draft-rollers, and the revolution of the tin rollers under the frame which determine the velocity of the spindles. Formerly the wheels were almost entirely uncovered; just

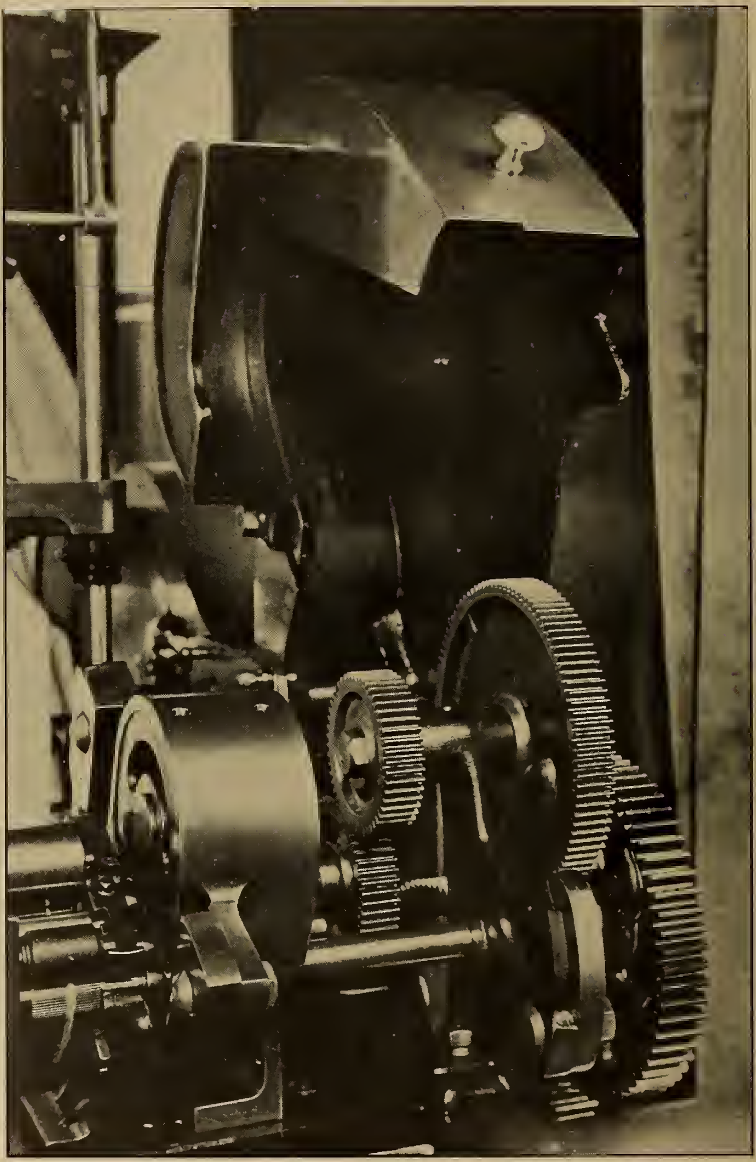


FIG. 9.—GEAR WHEELS AT END OF RING FRAME

a strip of fencing over the upper peripheries was all the safety provided. The sequence was a profusion of severe accidents. Fig. 10 shows the pair of levered guards now provided. Each is furnished with a lifting knob for use when inspecting the parts concerned while the machine is stationary. These guards are symmetrical and cover effectively the upper portion of the gearing; the lower portion is completely shielded by wrought-iron plates. These plates cannot be dissociated or laid aside inadvertently and forgotten; they are fitted to the frame of the machine and screwed firmly into position. Here also the driving-strap and pulley of the frame are located. These parts always demand

extra care when women's skirts are frequently passing. It is not uncommon for workers to be trapped between driving-straps and pulleys where these are unduly exposed; and such accidents are generally severe. To obviate these casualties the driving part of the ring-frame has been cased round (Fig. 11) so that neither straps, driving-ropes nor pulleys can come into conflict with operatives' clothing.

Where rope-driving is in vogue this safeguard is especially useful (Fig. 12). It prevents all rough or frayed strands doing damage to the workers should they perchance slip on the oily floor, or wheel round the machine in too close proximity. Ropes running on grooved pulleys have an inherent faculty for carrying all before them; arms and fingers would present very feeble barriers. The utility of this close casing tells its own pleasant story; accidents from driving-straps and ropes thus shielded are seldom heard of. The casing does not in the least deter from the practical working or efficiency of the machine; and the worker is moreover inspired with greater confidence as she follows the course of her employment.

A wheel which has in time past been intimately connected with severe accidents is that which engages the draft-roller pinions at A in Fig. 13. It is near the front of the machine, where the operatives' fingers are often busy threading or piecing the yarn. For this carrier to be uncovered would be a serious omission. It has, therefore, a substantial wrought-iron guard fitted and bolted to the fixed part of the machine. It cannot be merely lifted out of its position; nothing will remove it short of the overlooker's spanner when he desires to change the amount of attenuation in the yarn.

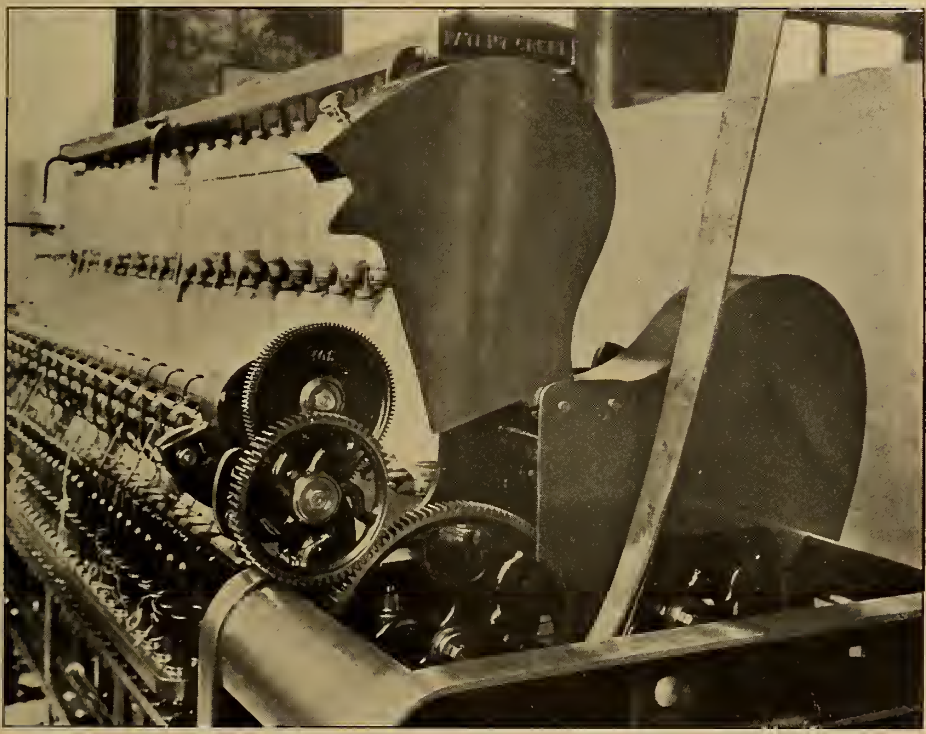


FIG. 10.—LEVERED GUARDS FOR GEARING OF RING FRAME

FIG. 11.—COMPLETE CASING AROUND END OF RING FRAME

This carrier is screened from the operative, whether she be piecing yarn or cleaning; all admission to its teeth is completely barred.

The wharves of the spindles are turned by bands (Fig. 14) mounted on a pair of tin-rollers, about 8-inch in diameter, placed between the roving-bobbins and the floor. These rollers are continuous from end to end of the frame and are separate from each other one or two inches; as a rule they revolve in opposite directions and gather in on the under side. Each spindle-band after leaving the wharve passes over the top of the near roller, under the farther roller, and returns over the top of the farther roller to the wharve. The reason for this arrangement is to

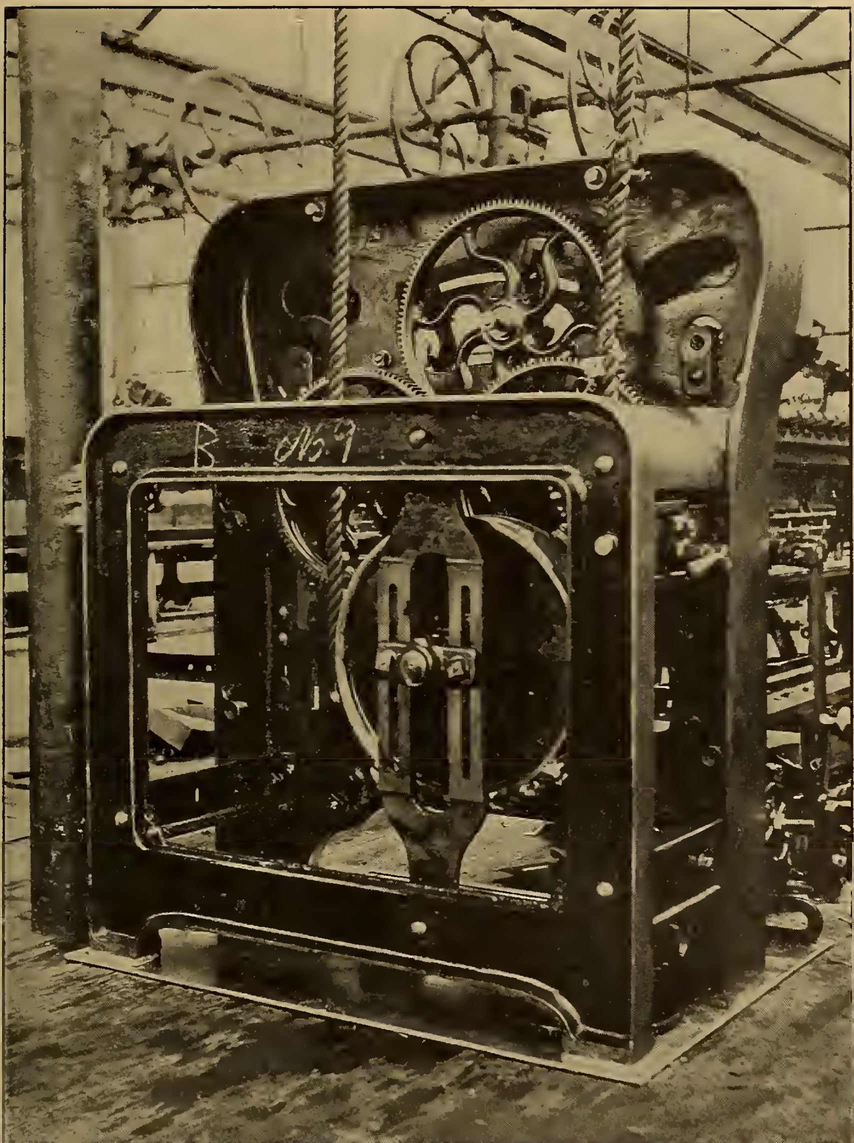


FIG. 12.—HEADSTOCK OF RING FRAME WITHOUT GUARDS

ensure the band passing round the wharve in a horizontal position. When one roller only was used there was great difficulty in keeping the bands on the wharves of the spindles; if the upper band were horizontal the lower one was at such an acute angle as to render permanent working well-nigh impossible.

But the substitution of *two* driving rollers for *one* created a very dangerous risk which was scarcely anticipated. Up to recent years it has been a common practice to thread spindle-bands while the machine is in motion, not of course all the bands on 400 spindles, but such as have snapped in the process of spinning. The general rule now is to stop the machine during this threading opera-

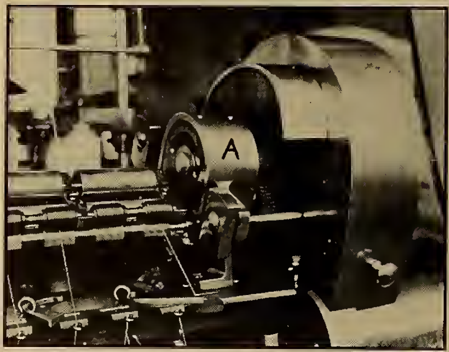


FIG. 13.—GEAR GUARDS, WITH CARRIER WHEEL IN A

tion as it is necessary for the hands to work near the danger zone, i. e., where the rollers in-gather. Even when the band is threaded through by means of a wire hook, there is danger when feeling for the loose end of the band while the machine is running.

A case in point may be cited which demonstrates the danger in a somewhat curious way. When a girl-tender was helping to thread the spindles she saw the loose end of the band suspended between the rollers but could not reach it from the front of the machine. The moment she, quite innocently, went under to reach the band a silken ribbon used for tying up her hair was seized by runing bands, the machine being in motion, and both hair and head were taken up between the rollers. The seizing power of these rollers is enormous; and it is scarcely possible for limbs to escape when once within their grip. The physical injury sustained is unusually severe, if not fatal. In other instances a hand has been lost while cleaning near the end of the rollers. Here a binding flange brings the peripheries slightly nearer than the rollers themselves. The cleaning cloth was caught up, and the hand followed involving total loss. Further, the cost of such accidents is no trifling matter. When a girl's right arm became involved in these rollers and had to be amputated, the compensation settlement amounted to more than three hundred pounds. Obviously the protection of such parts of a machine is in the best interests of employers and employed. To the former it saves time, untold worry, and heavy expenditure; for none can have a greater abhorrence to the injury of his workers than the employer. Besides, there may be substantial increase of insurance premiums where serious accidents happen involving large sums of money. To keep premiums at a low ebb there is nothing like prevention of industrial accidents. And this becomes increasingly momentous when insurance companies include in their policies certain conditions as to compliance with statutory requirements in regard to safety appliances. If A. B. desires to insure, he will probably discover that an insurance officer may desire to examine his plant to ascertain how far protection is afforded to the workers.

Ring-frame rollers should certainly not be approached when in motion. The risk has, to some extent, been mitigated by running both rollers in the *same,* instead of the *opposite* direction. By this method while one roller tends to draw in, the twin roller throws out any conflicting limb. Another plan, common in India and Continental countries, is to attach an iron rail the full length of the machine midway between the poker-rail and the floor. This prevents any "ducking under" the frame, and renders it impossible for piecers

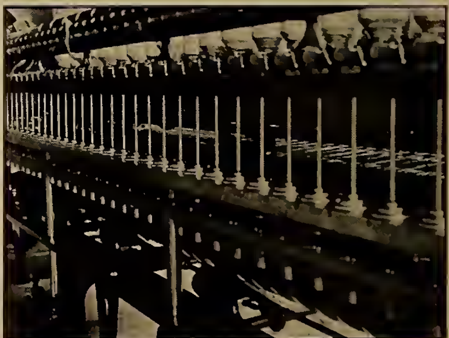


FIG. 14.—DRIVING BANDS ON TIN ROLLERS ON RING FRAME

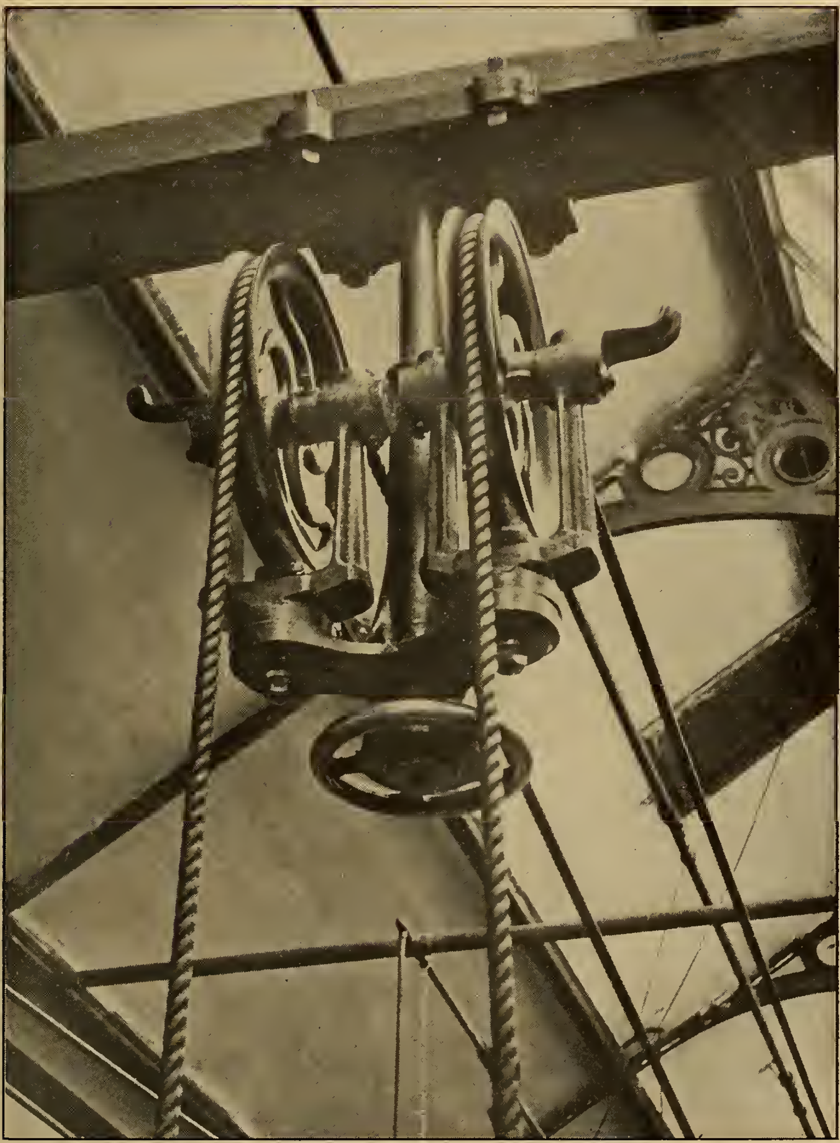


FIG. 15.—OVERHEAD PULLEYS FOR DRIVING RING FRAME

to reach the intake of the rollers. The open ends of ring frames should be completely closed by iron or planished-steel plates. This is done very effectively on all modern machines; older frames have merely a small iron tongue alongside the end of the rollers. This is quite inadequate when girls are cleaning adjacent parts.

Driving by ropes is a system which is gaining headway in ring-spinning. It promotes a steadier drive than leather belts, and is more easily controlled in case of lagging. Also there is less liability to sudden fracture than in the case of straps. Long before a driving-rope breaks it shows unmistakable signs of dissolution by fraying. Good splicing ensures the

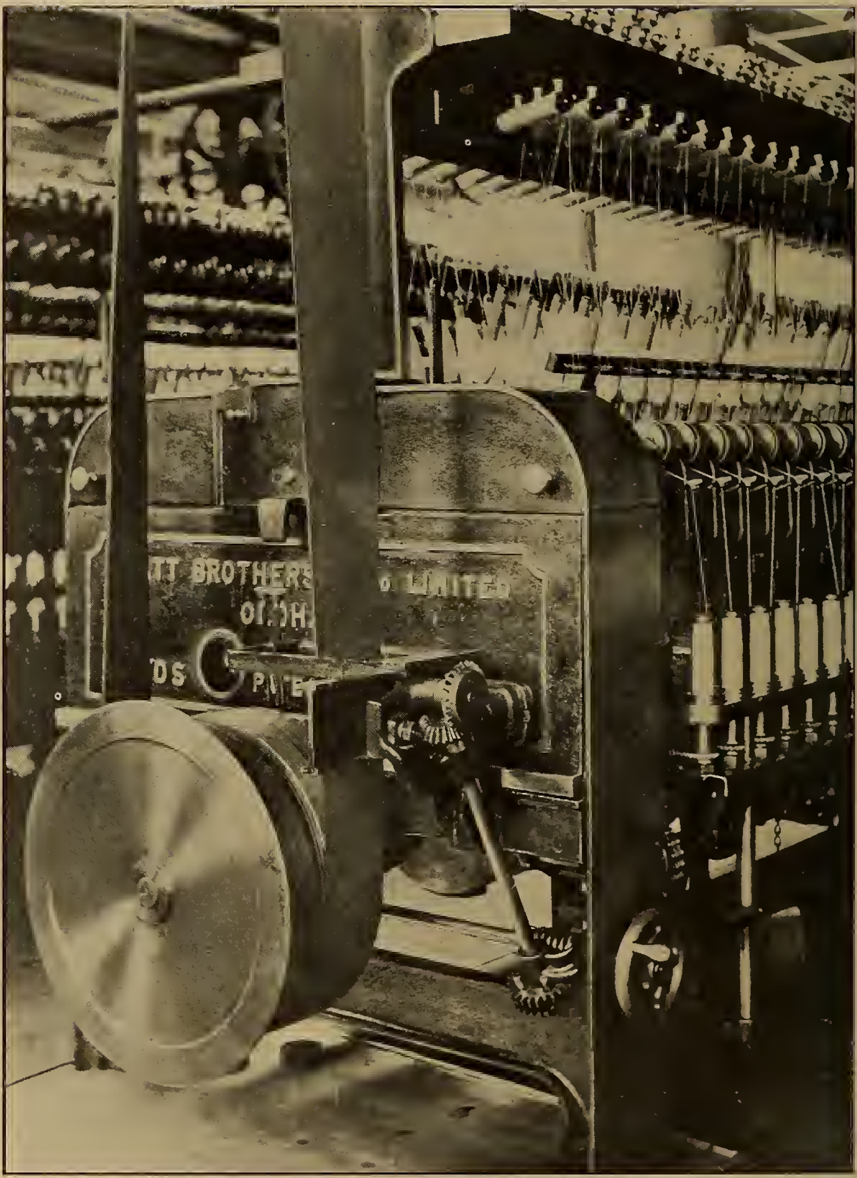


FIG. 16.—GUARDS OVER GEARING OF RING DOUBLING FRAME

constant wear of a driving-rope for an indefinite period. Grooved gallows-pulleys (Fig. 15) are fixed immediately over the driving pulleys of the machines, and in case of slackening of the ropes these may be easily adjusted by the hand-wheel until the rope attains a permanent setting. There is little probability of these ropes jumping the grooves of the gallows-pulleys; when unshipped they rest on the side hangers provided on the brackets.

Ring-doubling is a process following on ring-spinning, and is very similar in some of its operations. The ring-doubling frame (Fig. 16) does not "spin" in the ordinary meaning of the term; it twists two or more spun threads into one. It deals with

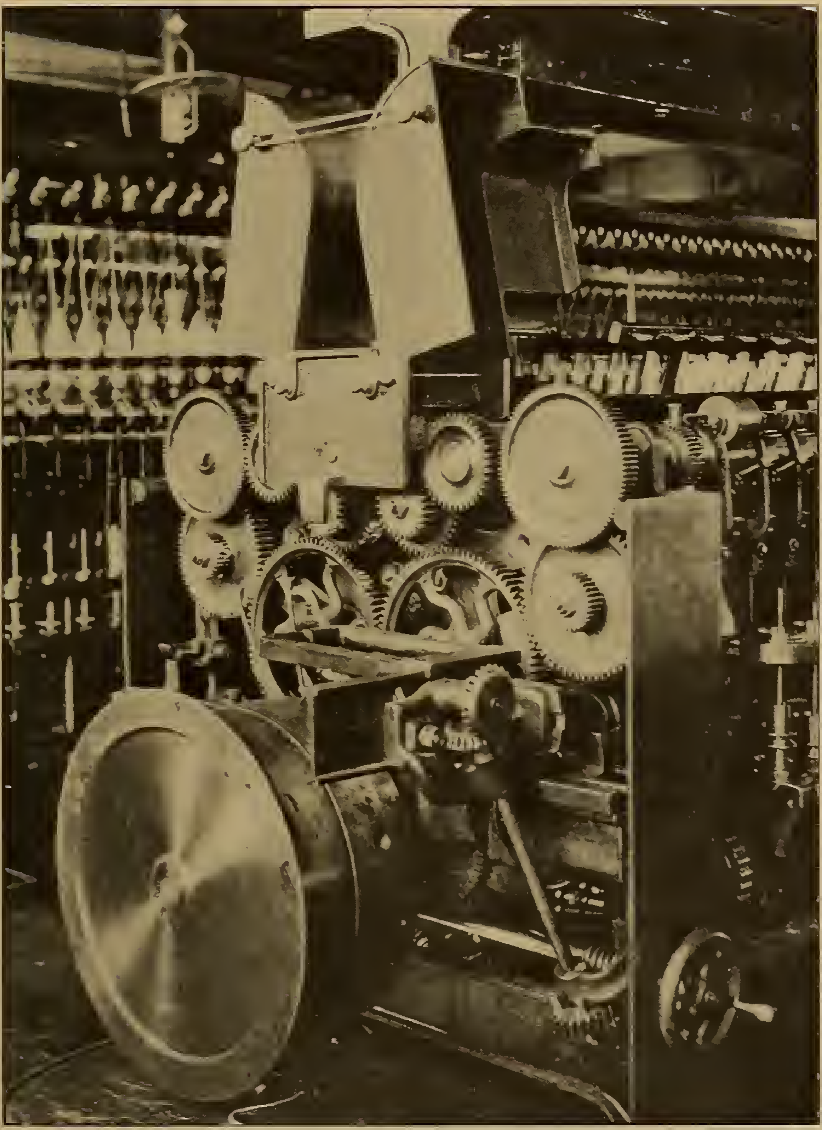


FIG. 17.—WHEEL TRAINS OF RING DOUBLING FRAME

cops, bobbins or pirns from the spinning frames, and has but one cylindrical tin-roller for driving the wharves of the spindles. It has no draft for attenuating the threads; one set of heavy rollers draws the threads from the cops or bobbins, they are then twisted by the revolution of the spindles and wound, as in the ring-spinning frame, by the traveling loop on the ring-rail which rises and falls. The mechanism of the ring-doubler embraces very important trains of cog-wheels (Fig. 17) which would, if uncovered, be fraught with serious risk to the operatives. Complete shield-plates are provided leaving only apertures for oiling; and where inspection is sometimes necessary levered covers embrace the dangerous wheels. The strap-forks are not intended to be

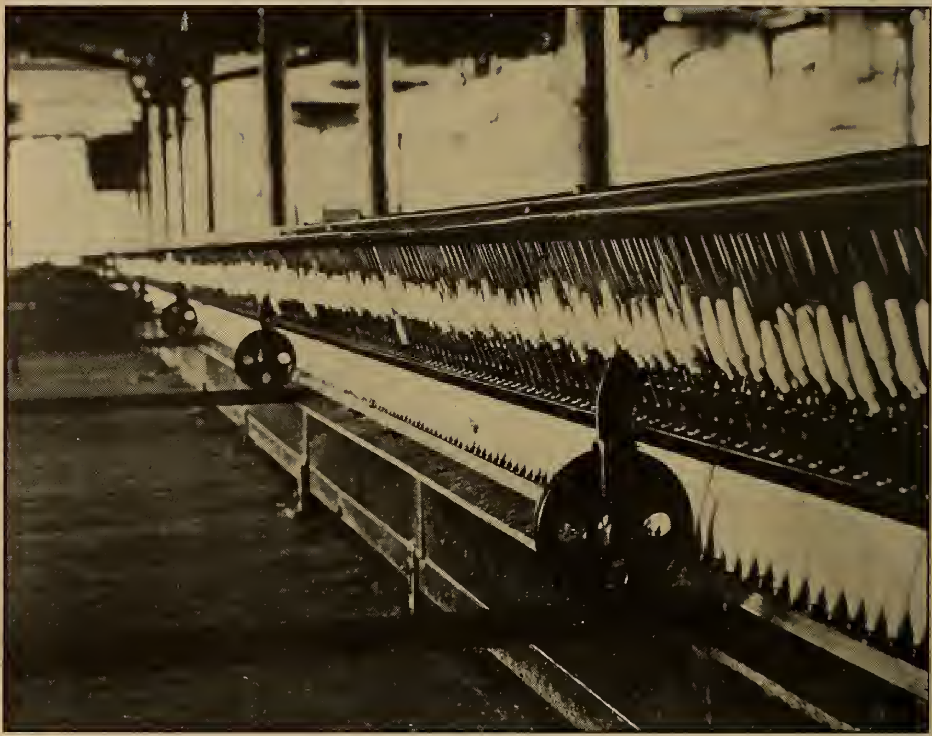


FIG. 18.—COTTON TWINER WITH COPS ON SKEWERS

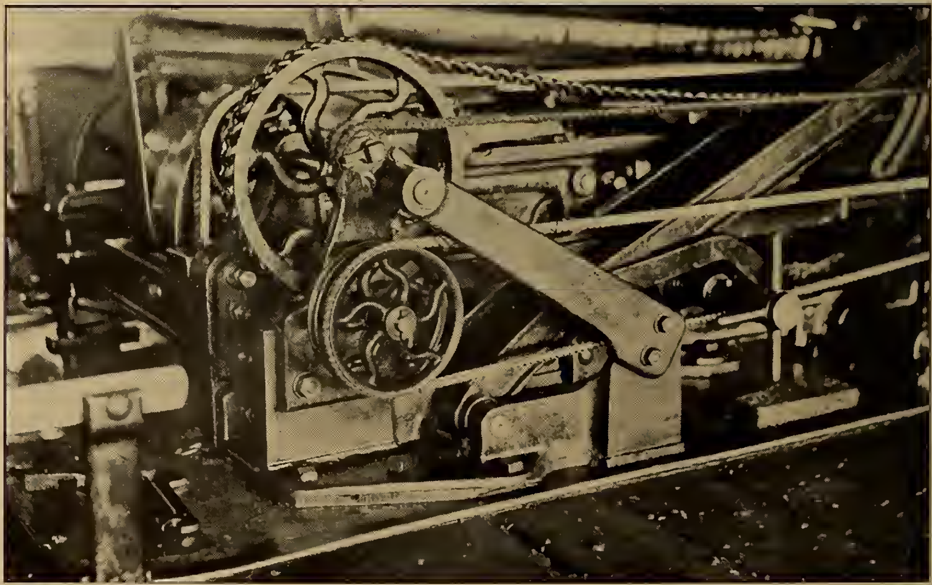


FIG. 19.—CHAIN WHEEL ON TWINER HEADSTOCK

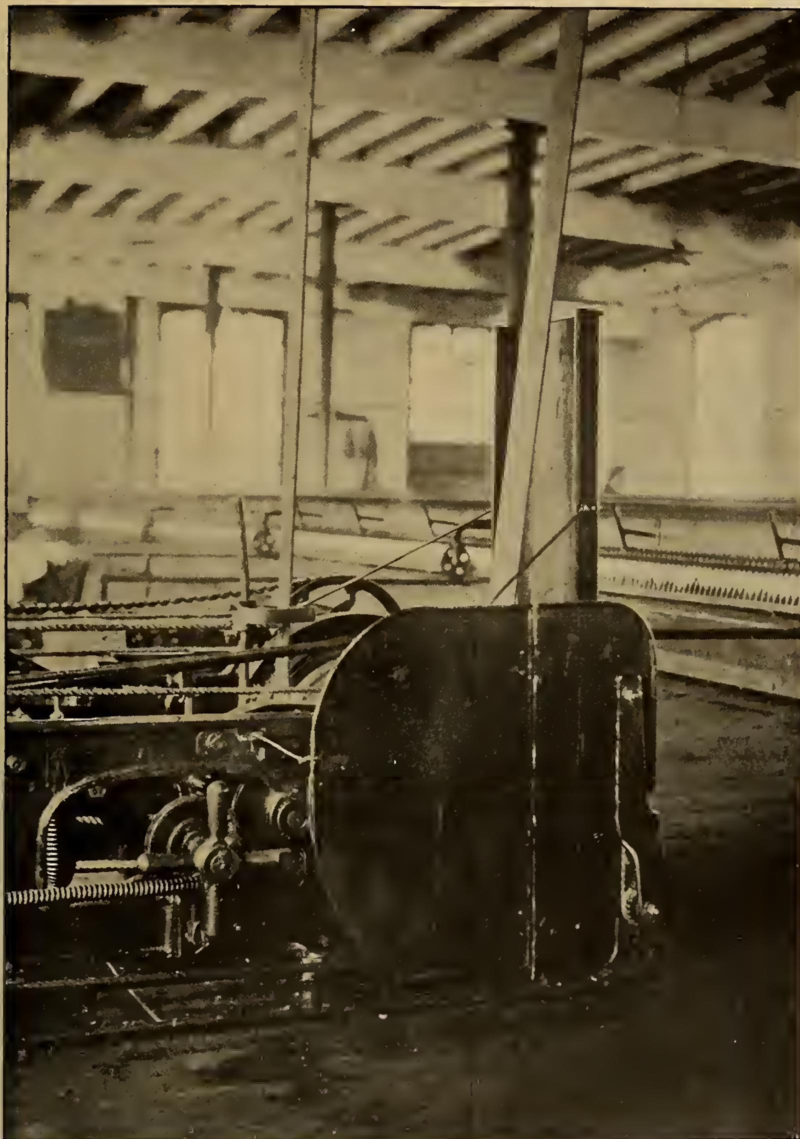


FIG. 21.—SWING-DOOR GUARD OVER RIM PULLEY AND PLATE GUARD TO DRIVING BELT

handled. The operating handle is placed, as a rule, some distance from the fork and connected with it by a bevelled rod and worm-wheel. By this means greater safety is ensured to the worker who is able to move the powerful strap is ensured to the worker who is able to move the powerful strap without risk. It will be further noticed that driving-pulleys are now faced solid, instead of being "spoked." Many casualties have occurred from hands and brushes being entangled in the arms of such wheels when revolving at high speeds near the floor.

Doubling is also performed by means of the twiner (Fig. 18) in which ring bobbins or cops are erected on skewers placed on a movable

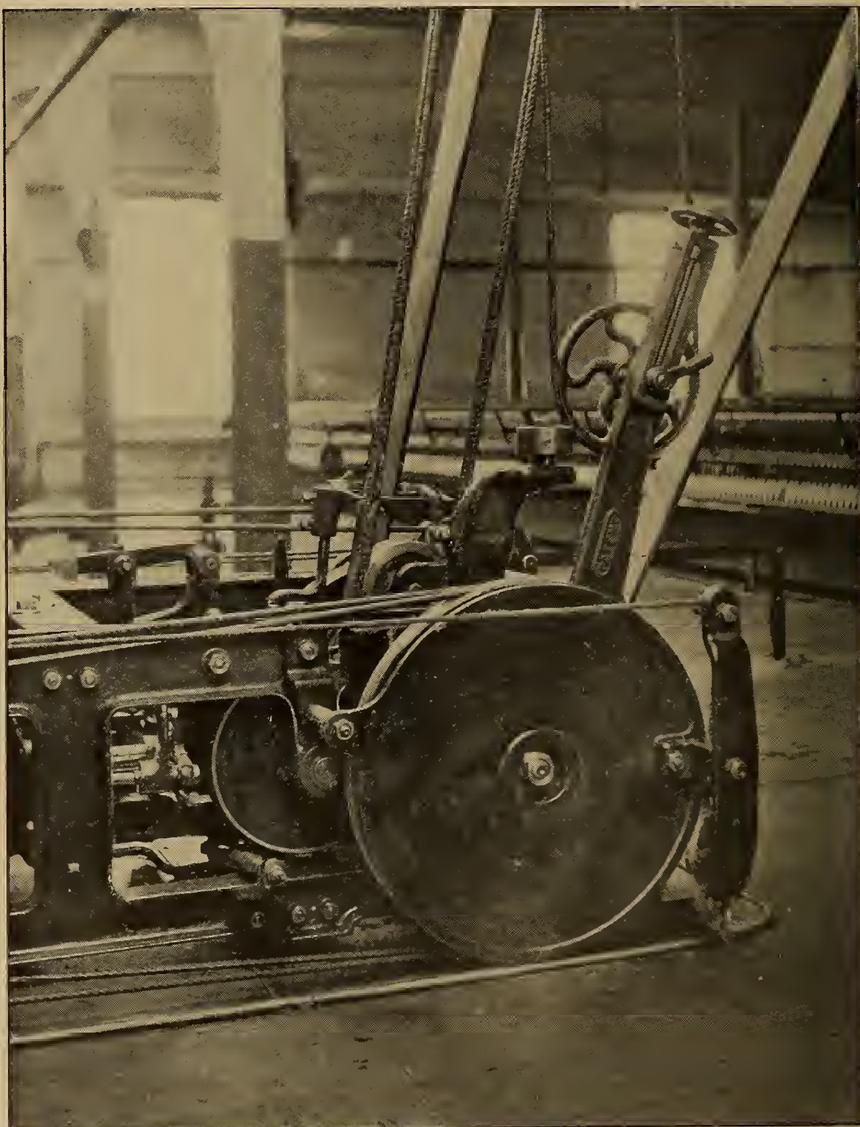


FIG. 22.—CAST-IRON GUARD OVER RIM PULLEY

carriage. As a rule two threads are combined as in the ring-doubler, but on occasions three or four threads may be combined to form one specially strong thread for hard textile fabrics. And although ring-doubling holds priority as a combination process, twining is likely to hold its own place for a long period as a producer of warp-yarn. In some respects it resembles the self-acting mule; but the traversing carriage which moves to and fro over a space of 60 to 72 inches bears the creel of cop-threads which are to be twisted; while the spindles with finished cops are erected on a fixed frame at the back of the machine. For half a century twiners have been running practically without safety-

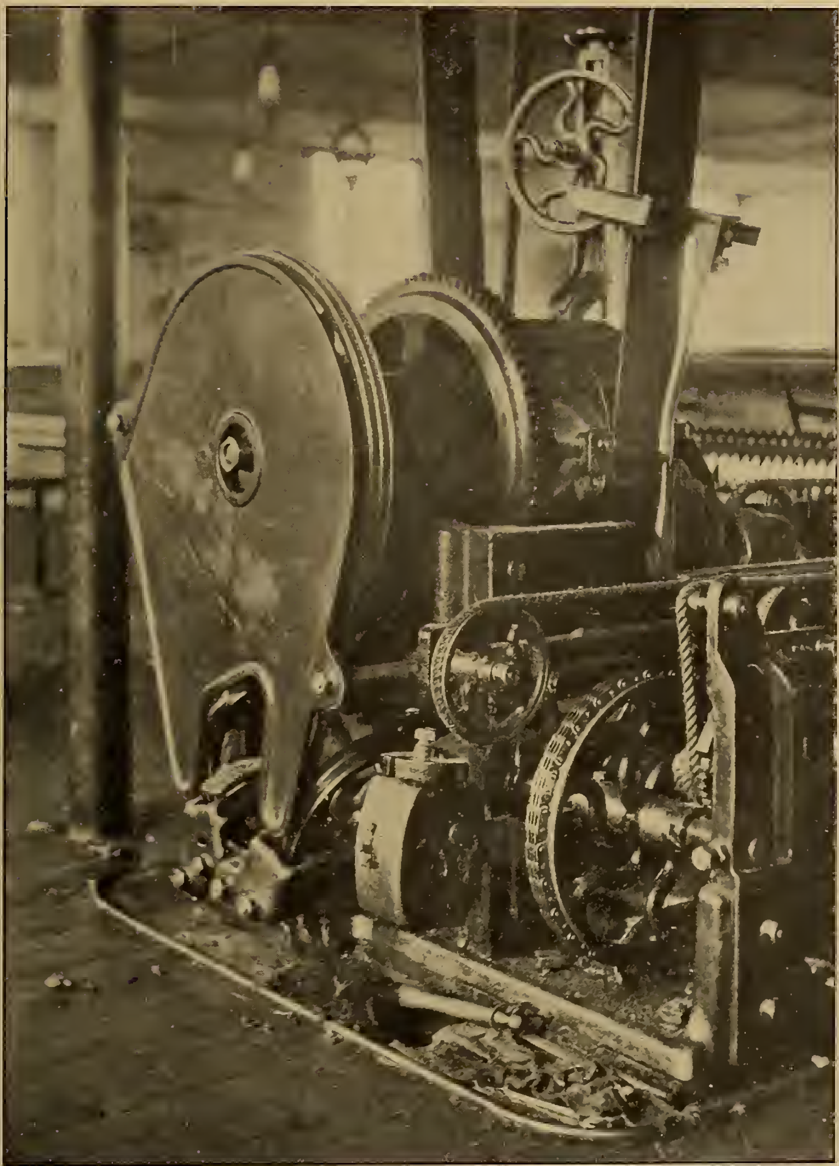


FIG. 23.—PLATE GUARD OVER FRONT RIM PULLEY

guards; but the occurrence of many severe accidents has led to the adoption of protective means, so that machinists and owners of twining mills have raised the factor of safety quite recently. The seat of greatest danger is in the headstock, which lies low near the centre of the machine and in the area of employment, so that workers are constantly passing and repassing. Dangerous cogwheels run within the headstock frame, and pulleys at the side or in front make over 700 revolutions per minute. It will be clear that if operatives—chiefly girls and women—slip and fall on these parts severe injury is likely to ensue. In this

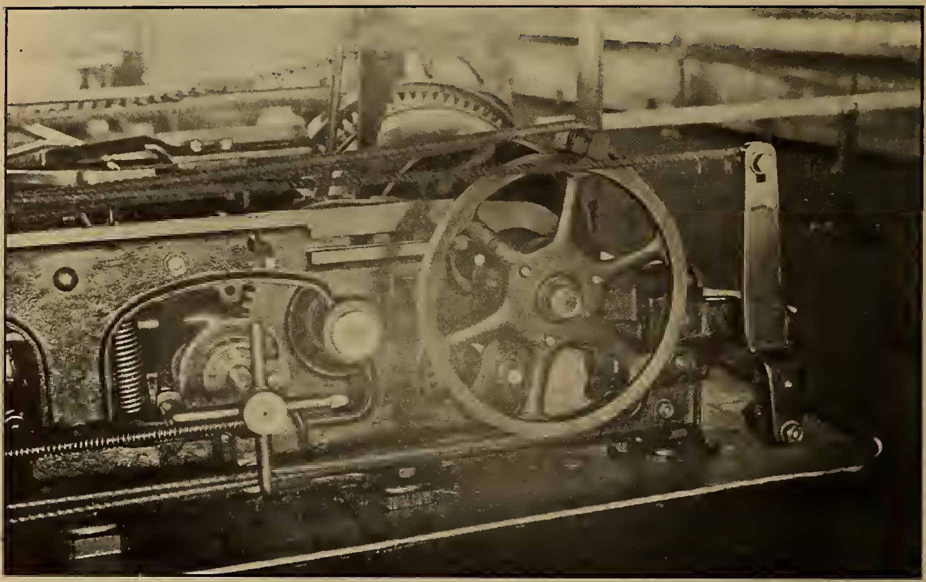


FIG. 20.—RIM PULLEY ON HEADSTOCK OF TWINER

FIG. 24.—WOODEN CASINGS OVER TWINER HEADSTOCKS

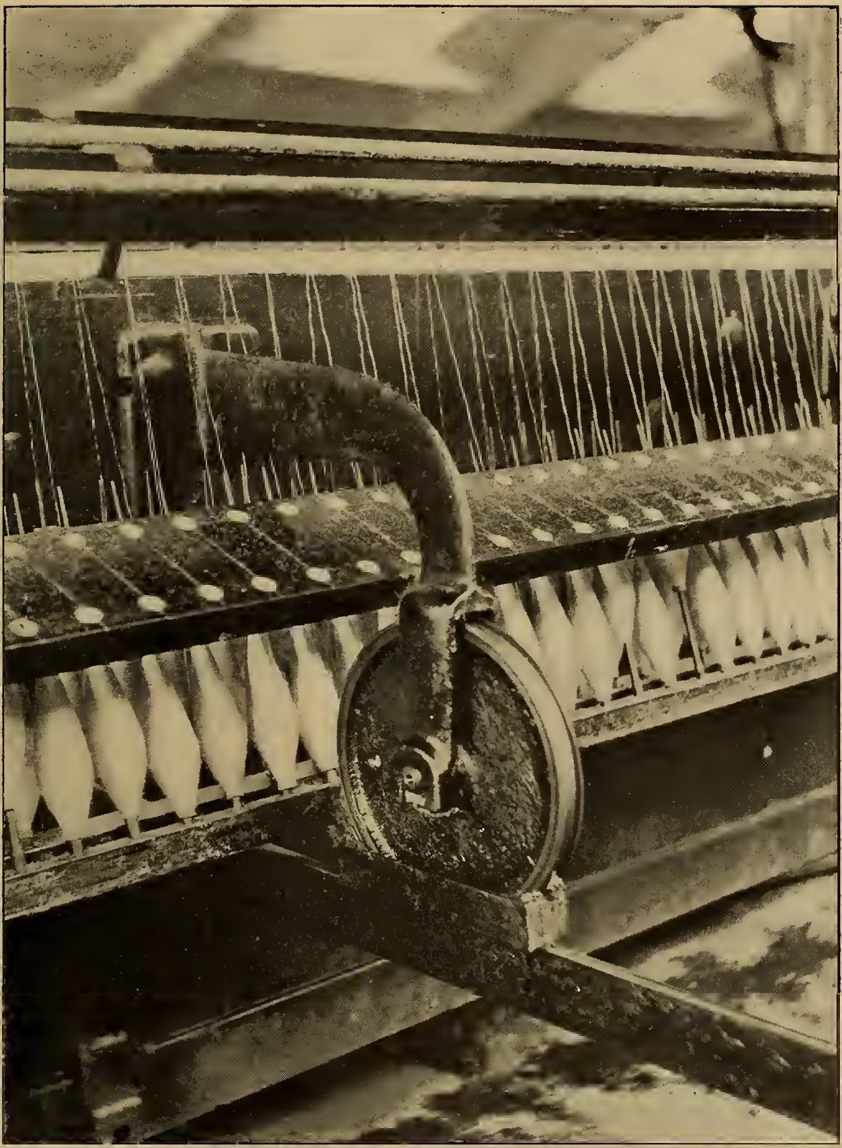


FIG. 25.—TWINER CARRIAGE WHEEL AND GUARD

manner fingers and portions of hands have been so badly mutilated as to require amputation.

Of the two sides of this headstock, the right (Fig. 19) is the less vulnerable. Here the chain-wheel revolves slowly and protects somewhat from the more dangerous parts beyond. But the left side (Fig. 20) often contains the rim-pulley, close to the floor and revolving at high speed. Fractured fingers and arms have come from collision with the spokes of these wheels. Guards are now fitted to old and new twiners, and such casualties are rendered impossible.

A simple and effective form of guard is shown in Fig. 21 on an old twiner. The owner was desirous of

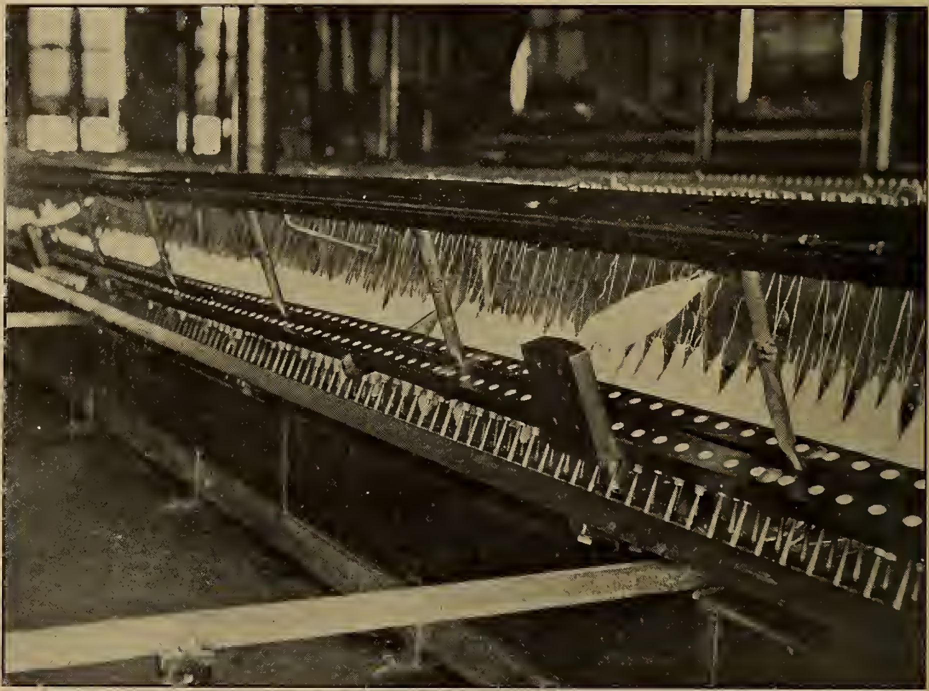


FIG. 26.—TWINER CARRIAGE WITH WHEELS INSIDE COP CREEL

FIG. 27.—GUARDS OVER CARRIAGE WHEELS ON END FRAME OF TWINER

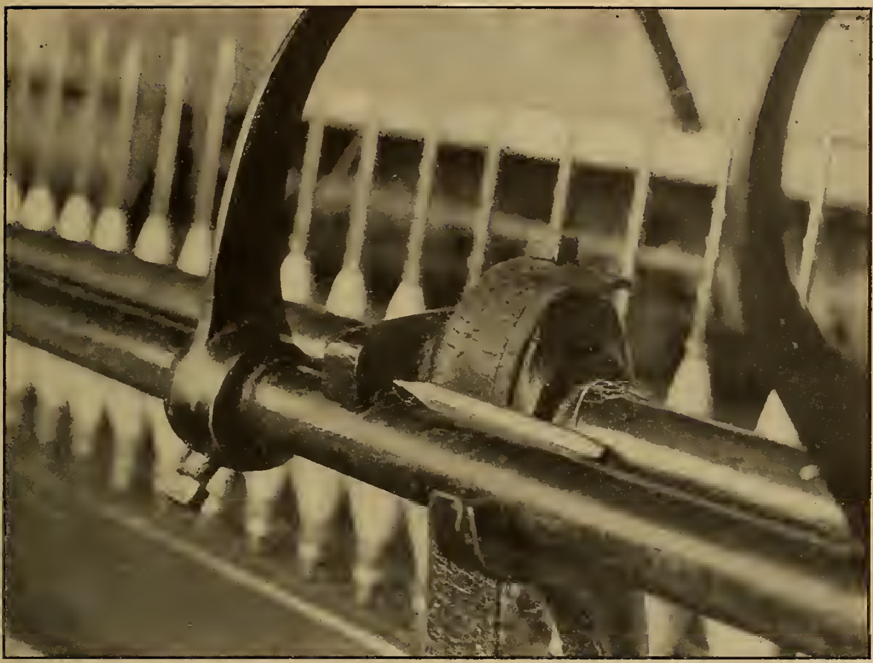


FIG. 28.—FALLER HAMMER OF TWINER, AT POINT OF PENCIL

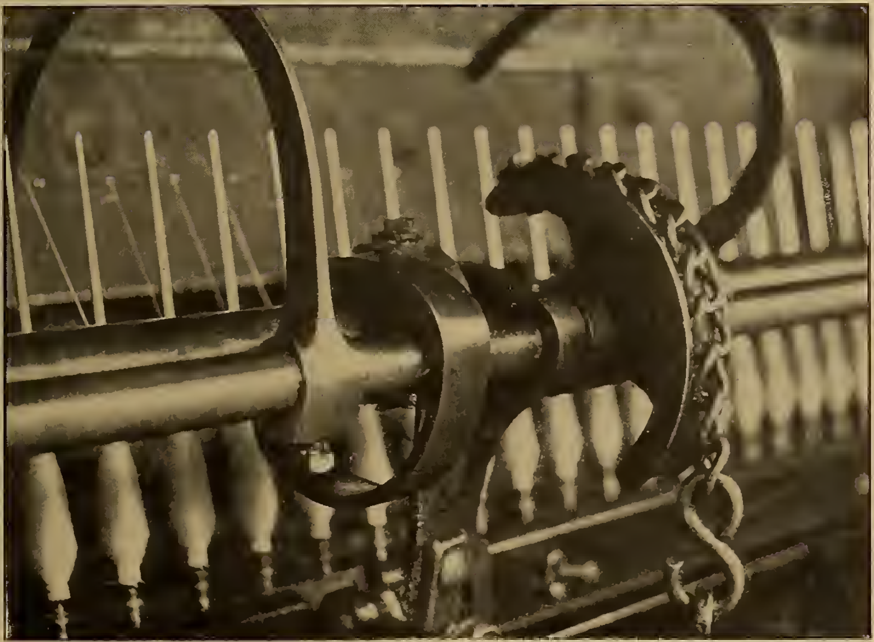


FIG. 29.—FALLER HAMMER AND GUARD COMBINED TO PREVENT FINGERS BEING UNDER THE HAMMER

FIG. 30.—CUT-OUT IN CREEL OF TWINER (CLOSE TO PILLAR)

saving his operatives from injury as far as practicable, and of minimizing his own risk under the Compensation Acts. He therefore planned his own guards and had them constructed to his own specifications. A fixed portion of the guard is attached to the floor-plate under the headstock frame; to this a swing-door is hinged and secured by means of a strong wire hook. The guard is firm and reliable, and covers the wheel entirely. New machines have their rim-pulleys guarded completely with cast-iron plates specially fitted (Fig. 22). With this type of twiner the main driving-belt is much exposed and liable to inflict injury; to obviate this substantial belt-guards are erected (Fig. 21) of planished steel-plates with flanges fixed to the headstock frame by stays of rod-iron.

When the rim-pulley is in the immediate front of the headstock (Fig. 23) the danger is increased. The incidence of accidents has demonstrated this. Cast-iron guards are now made which cover the whole surface of the pulley, and allow of easy removal for repairs or inspection purposes. Expense is sometimes urged against the general provision of guards. Even this may be moderated by adopting guards of wood (Fig. 24) made by the mechanic at the owner's mill. These are simple, effective and portable.

Next to headstocks the carriage-wheels do most physical damage.

These often project from the traversing carriage (Fig. 25) and run on steel rods or "slips"; the wheels are grooved to run on the edge of the slip, and no quarter is given if any finger should perchance come into contact with the wheel where it impinges on the slip. The carriage is heavy and the wheels destructive. An efficient remedy has been devised in the wheel-guard illustrated, which is merely laid on the slip while the wheel itself is lowered into its hollow cavity. The guard then travels to and fro propelled by the wheel. In some twiners (Fig. 26) provision has been made for these carriage-wheels under the cop-creel. They are then protected by the front creel-rails, which prevent any approach of workers' fingers.

Each twiner has a pair of carriage wheels running on the end of the machine-frame (Fig. 27). These being so proximate to passageways, should necessarily be well guarded. For this purpose specially-fitted guards are made of cast-iron, polished and fixed on the axles of the wheels. By their action any hand resting on the frame-end is pushed aside without injury. Faller-hammers (Fig. 28) are either covered with hoods or bent round (Fig. 29) in the form of an irregular circle, so that hammer and guard are combined in the same fitting.

Pillars in the central line of the jenny-gate—the space between the pair of twiners—have often been a source of trouble to mill-occupiers and operatives. The twiner-carriages in moving outward, come close to, or within an inch or two, of these pillars. Women and girls have suffered, in consequence, not merely an involuntary squeeze, but serious injury, from the close and sudden impact. So important did this risk become that it is now required by legal enactment that in new mills the outrunning carriages must not come within 18 inches of a fixed pillar. But the difficulty still arises in mills constructed 30 to 50 years ago, and to minimise it a portion of the front of the carriage has been cut out (Fig. 30) and levered with springs attached for practical working with safety. The operation of this cut-out is beautifully simple, and eliminates the likelihood of "traps." If an operative should be caught against the pillar while piecing threads, the front of the cut-out immediately bends in, the operative is not crushed, and as the carriage moves back the springs bring the front of the cut-out into line with the rest of the creel.

Ring-spinning, doubling and twining are indispensable processes in the cotton industry, and safe-guarding the workers in these processes is one of the employer's most valuable assets.

THE MECHANISM OF RIVER BEDS

By V. Lokhtine

II. THE PRACTICAL APPLICATION OF SCIENTIFIC PRINCIPLES.

(Concluded from the September issue.)

WE have now discussed the general conditions of equilibrium in rivers of moderate slope in resistent beds. The only force which a river possesses to relieve its bed from the deposits which encumber it, is its slope, and if the average slope is unable to attack the obstruction to advantage the river economises it, so to speak, by concentrating it first upon one portion and then upon another. During periods of high water the fall is concentrated in the deep places to clear away their deposits, and during periods of low water it accumulates in the shallows to remove the material which has been left there at high water, when the force of the current was insufficient to move it. Thus the various parts of the river, both deep and shallow, are indispensable instruments in the work of moving the deposits, and these different portions have their fixed limits, and constant positions, determined by the local properties of the bed.

The conclusions which have been already enunciated as following naturally and logically from the local mechanical conditions of a river bed, are fully confirmed by the observations which have been made upon the same subject. We have already referred to the longitudinal profile, very instructive for our purpose, of the noted shallows of the Volga, the "Téliatchy Brod," which, according to all historical records, has existed from time immemorial at the same place, about ten versts below Nijni-Novgorod. In times of low water these shallows have a total fall of 6.58 feet in a length of 12 miles which corresponds to a slope of 0.55 foot per mile; this is twice as great as the average of the Volga in the vicinity, which is only 0.2667 foot per mile. We see by the profile, that as the water level begins to rise, the steep slope begins to diminish, and when the level of the water reaches 34.16 feet above zero, the slope is only 0.1165 foot per mile. When the high water attains a level of 40.6 feet above zero, the slope falls to 0.087 foot per mile, or only about one-third the average slope of the river.

It is self-evident that with such a small slope the surface of this portion of the Volga presents the appearance of a great lake, extending far beyond its banks, and becoming a place for the deposit of a great quantity of suspended matter, which by its accumluation produces a reduction in depth above, causing an increase in the slope at low water.

This mechanical action of shallow and deep portions may be observed very clearly upon the examination of entire sections of various rivers. We may illustrate this point very clearly by the example of the River Garonne, already cited. In the accompanying table (Table III), compiled by M. Baumgarten himself, it appears that at low water the deep parts of the portion under consideration have an average slope of 0.0119 metre per kilometre, while the slope in the shallows at the same period is 1.020 metre, almost nine times that of the deep parts, and four times that of the average slope of the entire portion. With regard to the slopes in the deep and shallow portions during periods of high water, these are not given by M. Baumgar-

TABLE III.

SLOPES OF THE DEEP AND SHALLOW PORTIONS OF THE GARONNE BELOW ITS CONFLUENCE WITH THE LOT.
(According to M. Baumgarten. Ann. des ponts et chaussées 1848.)

	Shallows.					Depths.				
		Fall.		Slopes per Kilomètre.			Fall.		Slopes per Kilomètre.	
Kilo-mètres.	Lengths. Klm.	At Low Water. Mètres.	At High Water. Mètres.	At Low Water. Mètres.	At High Water. Mètres.	Lengths.	At Low Water.	At High Water.	At Low Water.	At High Water.
54.50						7.294	0.862	....	0.118	.....
61.72	1.172	1.370	0.62	1.168	0.528					
62.68						4.570	0.273	1.12	0.058	0.245
66.36	0.773	0.563	0.15	0.728	0.194					
67.16						2.545	0.197	0.48	0.077	0.188
69.83	0.773	0.633	0.03	0.817	0.038					
70.61						4.990	0.395	1.68	0.079	0.336
75.50	0.928	0.532	0.24	0.573	0.258					
76.50						2.405	0.357	0.55	0.149	0.229
78.89	0.509	0.732	0.18	1.438	0.353					
79.41						4.690	0.721	0.90	0.154	0.192
83.95	0.270	0.532	0.08	1.970	0.296					
84.27						1.472	0.221	0.37	0.150	0.251
85.86	0.429	0.943	0.13	2.200	0 305					
86.25						3.255	0.411	0.99	0.126	0.304
89.52	0.130	0.203	0.04	1.560	0.307					
89.65						5.299	0.210	1.68	0 040	0.317
94.82	2.173	1.610	0.26	0.741	0.119					
97.00						7.279	1.435	2.17	0.197	0.298
104.50	8.500	0.780	0.04	1.560	0.080					
105.00						1.716	0.098	0.62	0 057	0.061
106.75	0.754	0.677	0.07	0.897	0.093					
107.50						2.884	0.483	.....	0.167	...
110.35										
......	8.411	8.575	1.840	Mean. 1.020	Mean. 0.219	47.499	5.663	10 560	Mean. 0.119	Mean. 0.261

ten in his table, and we have been obliged to determine them from the longitudinal profile; the results are given in a special column of the table. It appears that in the shallows cited by M. Baumgarten, which present such steep slopes at low water, the slope diminishes at high water to an average of 0.219 metre per kilometre, which is lower than the average for the entire portion of the river under consideration (0.2546 metre per kilometre). In the deep parts, on the contrary, the slope, which is small at low water, reaches 0.261 metre per kilometre at high water, being increased about two and one-half times.

This profile is remarkable in that it furnishes evidence of the cause of the arrangement of shallows which results in the reduction of slope in the shallow portion itself and an increase of slope in the part immediately following. It is surprising that M. Baumgarten, who has given us such a complete analysis of the longitudinal profile of the Garonne, should have stated that at high water the slope always approached the average, and failed to observe such an evident circumstance.

This fact is, above all, essential, because the moment a diminution of the slope appears this latter cannot be caused by the natural conditions of the main bed of the river, nor by the secondary bed, which itself is formed by the high water and is the result of the energy of its currents. Herein appears the cause of an insufficient analysis of this question in the investigations of M. M. Fargue and Dubois, so remarkable in all other points.

If one is unable to explain the formation of river beds, it is because one has examined only the minor or secondary bed, and sought, by the analysis of its curves, currents, etc., to discover the causes of its formation, a proceeding which has led M. Dubois to avow that it was impossible for him to study the effects of high water upon the shallows.

There is yet another type of river with a resistent bed, of which another example has already been cited, the Dniester, of which both the bed and the banks have a high degree of resistance, the stream being divided into clearly defined portions of depths and shallows succeeding each other. It is possible in this river to observe the division of work in the transportation of sediment which oc-

curs in the displacement of the slopes of the deeper portions of the shallows and *vice-versa,* with the fall and rise of the water.

In fact almost two-thirds of the portion under examination, about 133 miles in length below Mohilev, presents regular and deep sections, with a tranquil current and an average slope of 0.45 foot per mile at low water, while the remaining third consists of shallows with a rapid current and an average slope of 2.34 feet per mile at low water.

At high water, as on the Garonne, this distribution of slopes is changed, and in the deep portions it rises to 1.12 feet per mile, while in the shallows it drops to an average of 0.882 foot per mile; these figures show again the action of a succession of depths and shallows which is characteristic of rivers having resistent beds.

We believe it to be unnecessary to multiply examples, or to compare the slopes of different portions of various rivers, indicating the manner in which equilibrium is established between the comparatively feeble current and the relatively high resistance of the bed.

As a matter of fact, in the literature of hydraulics there are to be found very few longitudinal profiles of rivers given with sufficient detail at high and low water to be available for the question in which we are interested, and still fewer in which the data are so given that we can separate the slopes at low and high water.

It would even suffice to have the longitudinal profile at low water, and if this profile presented the form of a sort of stairway by reason of its succession of steep and moderate slopes, this fact alone would indicate the insufficiency of the slope as opposed to the resistance of the deposits and furnish the distinctive characteristic, classifying the stream among those possessing a resistent bed. In any case, without again citing the profiles of rivers in the same category, we may pass to the second property due to the same insufficient slope—the periodical deposit of sediment upon the shallows, due to diminution in the velocity at these points during periods of high water. This phenomenon is a logical sequence of the reasoning already given upon the properties of longitudinal profiles, that the displacement of slopes should be confirmed by direct observations if the conclusions were correct. As a matter of fact, the inhabitants have observed, upon many rivers, that during the periods of high water the shallows become obstructed with sediment, and that they cleared themselves and became deeper during low water, even during the continuation of low-water periods. Examples are known where in certain shallows, after a sudden fall from high water, the bed was found so obstruced with material deposited when the level was high that navigation was interrupted until sufficient time had elapsed for the low-water current to displace the deposits.

Nevertheless, although isolated and wholly characteristic examples of this sort have been observed for a long time, the phenomenon has not been studied as a whole until recently, when a very practical reason has directed attention to the question. This reason was the results of the action of the barrages, or movable dams, erected on the Volga for the deepening of the shallow portions. In order to obtain an understanding of these results, by no means satisfactory, it has been necessary to investigate whether the deepening of the shallows observed in certain cases during low water was due to natural causes or was effected by the dams. With this end in view, the engineer, Makarov, undertook a detailed study by making a simultaneous comparison between the levels of the water and the depths of the shallows.

Briefly, M. Makarov gathered the facts relating to 75 shallows on the Volga, from June 1 to October 1, for five years. He prepared 350 dia-

grams which showed the changes in the level of the bottom of the shallows with respect to the level of the water. It is unnecessary for us to cite here all the figures and diagrams of M. Makarov, and we must refer those who are interested to the original work; we believe it will amply suffice to give the conclusions of the whole study, which demonstrate positively our supposition of the periodical obstruction of the shallows, indicating the remarkable constancy with which the bottom of the river rises and falls with the rise and fall of the water. We may remark that the data concerning the depths at the shallows given in the investigation of M. Makarov are taken from the reports made by the official observers stationed at these points. These reports are worthy of entire confidence, on account of their importance in connection with the control which they exercise over the navigation of the river. As regards the oscillations of the surface of the water, a direct measurement was made only as the scale at the shallow of Kouchnikovo; at all other points, owing to the absence of a hydrometric scale, it was necessary to resort to interpolation between the heights noted at the two neighbouring scales. The small errors inevitable in interpolations of this sort were doubtless counterbalanced by the number of the observations and could alter the conclusions only from a quantitative point of view, without affecting the general principle in which we are interested. Further, at the shallows of Ourakovo, where there is a hydrometric scale, there appears the same fact of the elevation and depression of the bed with the rise and fall of the water level.

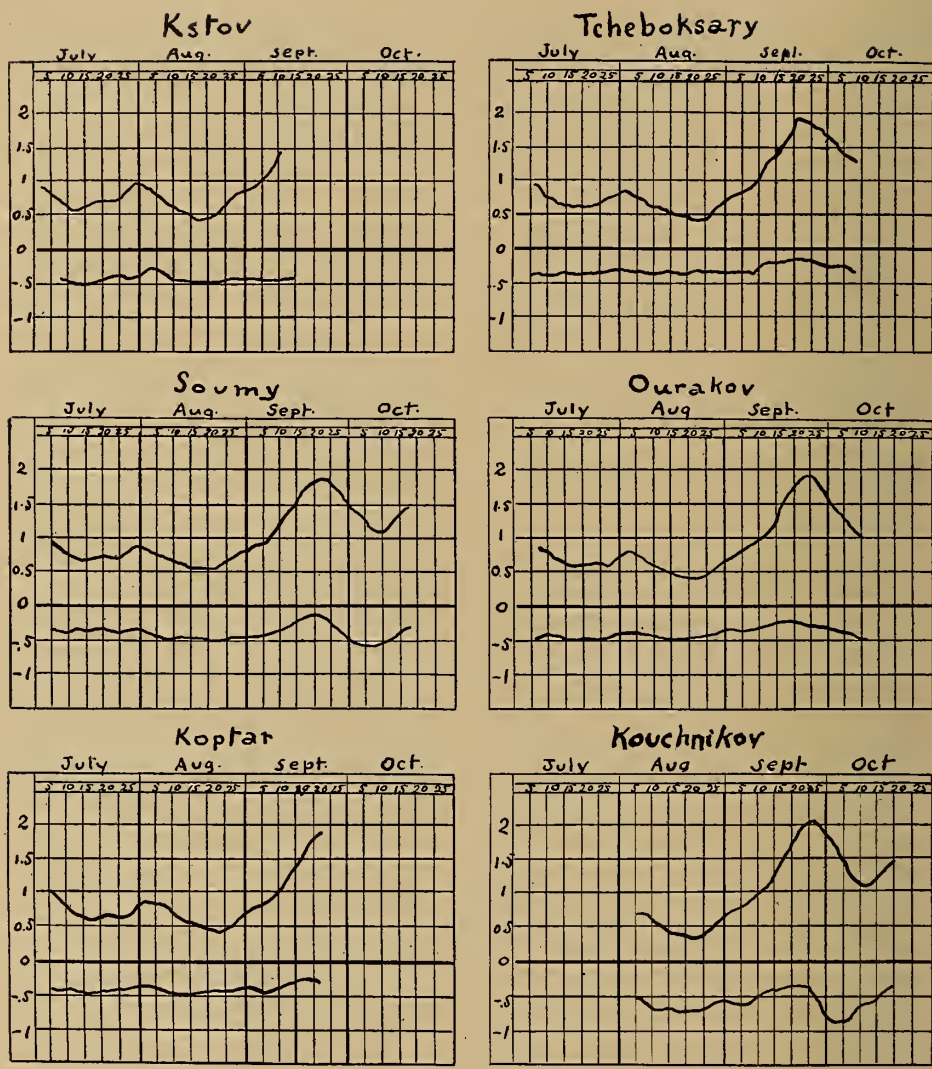
Nevertheless, to remove still further this possible source of error, 12 hydrometric scales were installed in 1894 directly at the shallows, thus making it possible to follow directly the variations in the level of the water as well as of the bottom. The results of these records are given in the accompanying diagrams, giving even more positive evidence than the observations of M. Makarov. We may draw the same conclusions from these diagrams, and perceive the remarkable parallelism between the curve of variations in water level and those of the bed of the stream.

These observations of 1894, as well as those of M. Makarov, were made at a time when the level of the water varied between comparatively narrow limits, not nearly approaching the highest level of the Volga. In fact, we believe that it would be extremely difficult to measure the depth of water over the shallows at that period. In consequence, the fact of the periodical diminution in depth cannot be attributed to the deposits of sediment made at high water, and the following explanation becomes necessary:

When the water rises, the sand deposited on the shallow is submerged, and the current flowing over these deposits follows a more direct line than during periods of low water, when the sand-bar is filled with irregular channels which have cut their way through. However this may be, and although such observations are necessarily limited, in the present instance, for the oscillations of the Volga during the summer season, they show, nevertheless, that the sand is brought by the current from above, down upon the shallows during the period of rise of the water level, and that it is carried on farther down the stream as the high water subsides, showing that mechanism of the shallows in a river with a fixed bed is as we have already indicated.

Returning now to the question how rivers of moderate slope and fixed and resistant beds attain a condition of equilibrium and prevent their comcomplete obstruction by deposits of sediment, we may draw the direct conclusion that *this equilibrium is obtained by the temporary concentration of the slope at the point where it is most necessary during the momentary level of the water.*

The constancy of the position of

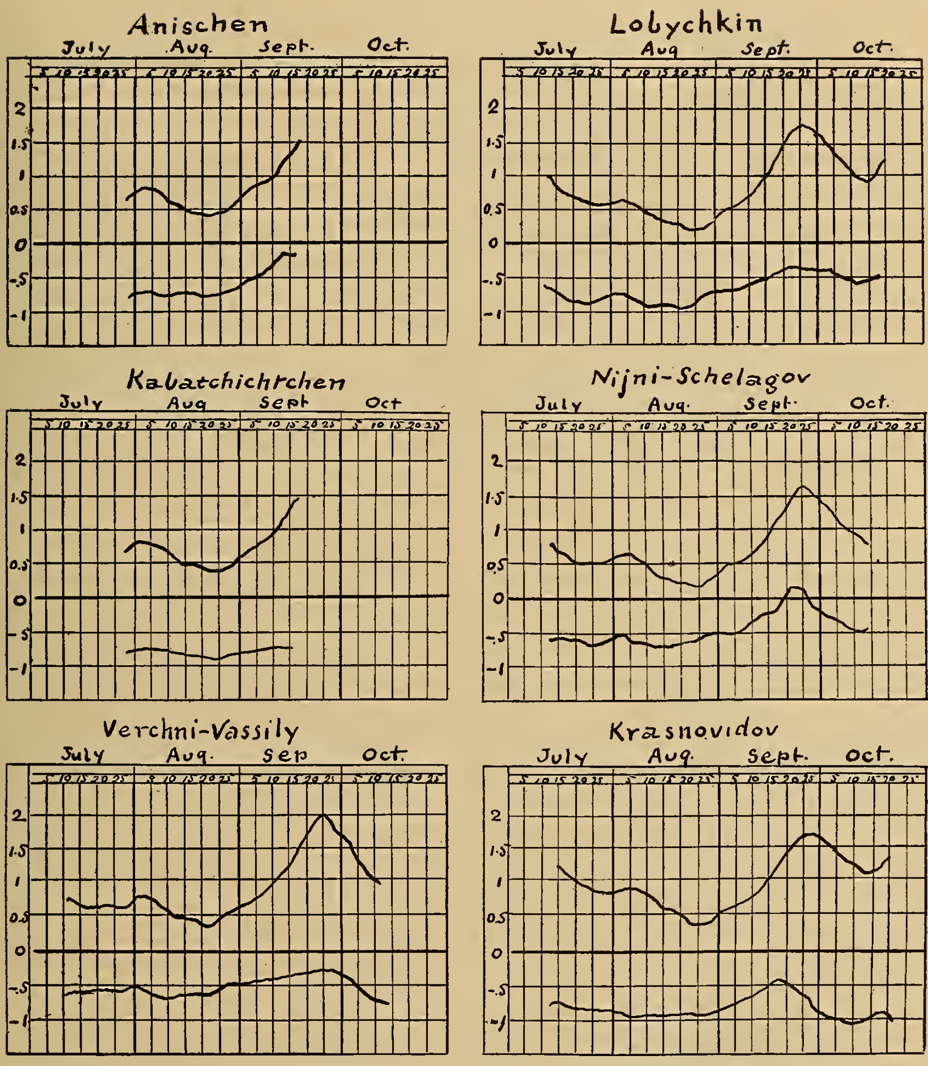


DIAGRAMS SHOWING THE RELATION BETWEEN FLOOD LEVELS AND BOTTOM CHANGES IN SHALLOWS OF THE VOLGA

shallows, which do not shift their places, the sharp division between shallows and depths, the staircase form of the profile of the river, the displacement of the steepest slopes from the shallows to the deeper portions during the rise of the water, and the inverse phenomenon during the fall in level—these are the characteristic traits of rivers with resistant beds, and such are the conditions of their immutable existence in the state of equilibrium which they have attained during a long period of centuries.

Let us now suppose that the general slope of the river increases and that the resistance of its bed remains unchanged (the action would be more marked if the resistance diminished).

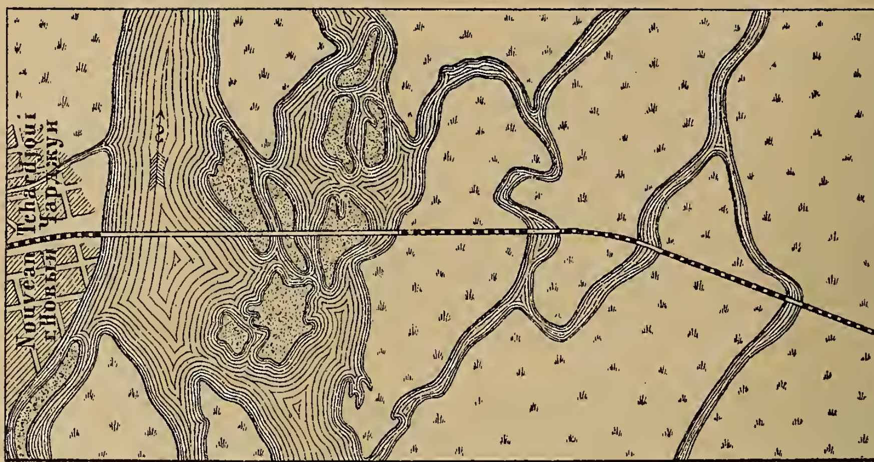
Under such circumstances the clear and sharply defined character possessed by the stream would gradually become changed. Its shallows would become less pronounced at low



DIAGRAMS SHOWING THE RELATION BETWEEN FLOOD LEVELS AND BOTTOM CHANGES IN SHALLOWS OF THE VOLGA

water, their position would become less stable, temporary sand-bars would be produced here and there, according to circumstances; the river, considered as a whole, would lose its fixed character and become more mobile, and its longitudinal profile, both at high and at low water, would lose more and more its resemblance to a stairway.

Upon the supposition of an increasing augmentation of the slope, or of a slower diminution in the resistance of the bed, all these properties would become more pronounced, and there would ultimately be reached a point at which the slope would become equal or superior to that necessary to maintain the continued support of the entrained material. It will then no longer be necessary for it to make periodical deposits of sediment because of inability to sustain the entrained matter. From this moment the condition of the river passes from that of



THE AMU-DARIA AT THE CROSSING OF THE TRANS-CASPIAN RAILWAY, SHOWING ITS CONDITION IN 1888

stable equilibrium to one of unstable equilibrium. This state is characterised by the preponderance of the excess energy of the current, which has a force capable of carrying along with it all obstacles encountered in the movement of the water, without the necessity for the concentration of its power for this purpose at any particular points in the profile. At the same time the local conditions which, in rivers having a resistant bed, cause a definite distribution of steep and moderate slopes at high water, no longer play such a part. With the preponderance of the force of the current, and with a bed of insufficient resistance, the least concentration or augmentation of the slope causes a solution of the earth so rapid and energetic that the eddies thus accidentally formed are almost immediately destroyed, and the slope re-established.

Apart from any local and accidental increase, the average and uniform slope along the entire length, steeper than that which is consistent with a state of equilibrium of the river-bed, while at the same time the least slope possible under the conditions produces at high water such

CHANGES IN THE AMOU-DARIA IN 1889

CHANGES IN THE AMOU-DARIA IN 1890

a great velocity that the flow of the stream is necessarily accompanied with a destruction of the bed and the banks, and continuous erosion of the entire surface of the bed.

It is in this expenditure of the excess energy, and in the removal of the products of this destructive action, that Nature finds the means of arriving at equilibrium in such a case. The current demolishes a tongue of land at one point to form another somewhere else; it cuts down one bank to increase another; it cuts for itself a new path and establishes a new bed to abandon the old one, which becomes rapidly filled up.

As an example of such action let us take four illustrations of the plan of the Amou-Daria and the point where it is crossed by the Trans-Caspian Railway. The plans represent the situation in four consecutive years, and the contours of the river and its branches appear in such different positions that it seems almost impossible that they belong to the same river. Such a plan of a river having a bed of low resistance and excessive variation is the natural consequence of a current too powerful for the resistance of the valley. Equilibrium can be es-

CHANGES IN THE AMOU-DARIA IN 1891

tablished only by the continual contest of the banks with the current, at the expense of the displacement of the course of the stream along its length. The only possible state of equilibrium in such a case lies in the dynamic changes in the bed; the only possible form of longitudinal profile is that of a straight line of uniform slope of fewest inflexions, and of an essentially temporary character, caused by the eddies due to the material deposited by the high water following rapid subsidence, only to be formed again in a different shape at some other point.

These conditions of current in a bed of low resistance may be expressed in figures, if we are comparing two rivers of different character. Let us take, for example, the Dniester and the Vistula, which have their origin near each other on the watershed of the northern Carpathians, and flow, one northward to the Baltic, and the other to the southwest of the Black Sea. These rivers, as we shall see, possess in their natural condition very different characteristics.

The Dniester, as we have already seen, has in its upper portion an average slope of 0.99 foot per mile, and during periods of low water it presents a succession of tranquil depths occupying about two-thirds of the length of the river, separated by shallows with rapid currents having average slopes of about 2.31 feet per mile, and attaining, in some cases, slopes as high as 7.35 feet per mile. Such high slopes at low water, and consequent velocities of 3 to 7 feet per second, necessarily act, as has already been shown, to remove the deposits from the shallows. These deposits consist of a mixture of sand, mud and coarse gravel; some pieces of the latter reaching a size of 5 to 10 inches, and having an average size of 1 to 4 cubic centimetres, as shown in the accompanying table. These sizes have been determined by the direct measurement of a number of samples taken from a considerable quantity of the deposit:

Distance from Austrian Frontier, Miles.	Name of Locality from which Sample was taken.	Pieces of More than 0.2 cc. Per Cent.	Sand, Mud, etc.,	Spec. Grav.	Mean Wt., Grammes.	Mean Vol. Cubic Cm.
1.30	Ivanetz	64.30	35.70	2.60	4.27	2.77
30.00	Oustie	43.00	57.00	2.15	8.66	4.03
172.00	Soroki	63.45	36.55	2.43	6.59	2.70
240.00	Kamenka	55.46	44.54	2.56	4.03	1.57
250.00	Erjev	47.16	52.84	2.53	2.66	1.05

We thus have the distinctive characteristics of the Dniester; an average slope of 0.99 foot per mile, and a bed consisting of gravel of 1 to 4 cubic centimetres.

Let us now examine the comparison of the bed of the Vistula. The slope of the course of the stream in Russia is 1.55 foot per mile; that is about one and a half times that of the Dniester, while the sediment, in place of coarse gravel, consists of mud and fine sand, of which the particles, measured by a method described hereafter, do not exceed 1-16 of a centimeter in diameter.

With a slope sufficiently steep to produce currents having velocities of 3 to 4 feet per second at low water and as swift as 7 feet at high water, on one part; and with material sufficiently fine, on the other, there is no question of any particular stability of the bed, of any division of the stream into deep and shallow portions, of any stairway longitudinal profile, nor of any local increase in slope, becoming necessary for the transport of material. Under such circumstances the entire bed presents the aspect of a continuous obstruction, continually being removed and displaced by the excessive force of the current. The whole river appears as a wandering stream of uniform slope, and with a continually varying depth.

Such are the solutions which are presented by Nature in the two extreme cases, that of a small slope and

a resistant bed; and that of a steep slope and a bed of insufficient resistance.

It will be apparent that in the preceding examination, we have taken, for the sake of simplicity, the two extreme cases and types of equilibrium, and that between these there may be interpolated all other types of rivers characterised to a greater or less degree by fixed or varying beds. The classification of a river into one or the other of these categories, very important, as perceived, from a hydrotechnic point of view, can be made only after a critical study of its longitudinal profile and of the materials which it carries in suspension.

Unfortunately the present condition of the science of hydraulics does not permit us to translate the movement of water in rivers into precise formulas, and if we attempt to use this method in the present case, it is only because we desire to exhibit the correlations which we have established, and not to attempt the deduction of any numerical results.

Let us suppose that each particle of entrained material has the form of a sphere (in reality it approaches an ellipsoidal form, the measurement of a large number of particles giving the relation of diameters of 1 : 1.64 : 2.43); also let d be its diameter, f its coefficient of friction, w the weight of a unit of volume, and p the resistance which the particle opposes to movement; we then have:

$$p = f w \frac{\pi d^3}{6}$$

and if we designate by c_1 the product of the constant factors, we have:

$$p = c_1 d^3.$$

We also have acting upon this element the pressure P of the moving water equal to

$$P = W \frac{V^2}{2g} \cdot \frac{\pi d^2}{4},$$

in which W is the weight of a unit of volume of water, and V the velocity of its motion. We may remark here that we must not commit the error of taking for the value of the velocity that obtained in the river after it has surmounted all the resistances of its bed, and given by the formula

$$V = k \sqrt{r i}$$

as a function of the slope and the wetted perimeter.

If we imagine two water courses, identical in all particulars except that the bed of one is covered with a layer of sediment, while the bed of the other, while of exactly the same form and dimensions, is entirely smooth, the minimum velocity in the first of these currents will be the resultant of the force expended in overcoming the resistance of the sediment and entraining it. These resistances are included in the formula $V = k \sqrt{r i}$ under the form of the coefficient of friction of the water against the bottom and the wetted perimeter and by the introduction of the slope in place of the total head which causes the velocity of the accelerated movement of the water along the river. The problem in the present case consists in expressing the properties of the river to the extent to which it carries the suspended material; this is, therefore, not the definite velocity finally produced in the bed and determined by the preceding formula, and which is that of the mass of water traversing the portion under consideration.

Rather is it the kinetic energy expended per unit of length, determined by the total fall of the river upon this portion and given by the formula:

$$V = \sqrt{2 g h}$$

If this result is relatively too great for the resistance of the material, the bed will be subjected to a continual destruction, while in the contrary case it will be more or less permanent. If we substitute in the expresssion for P the value of $V = 2 g h$, collecting all the constant factors under a single expression c_2, we shall have

$$P = c_2 h d^2,$$

and comparing this value with that of p, we have:

$$\frac{p}{P} = C\frac{d}{h},$$

from which we see that the fixity of the bed is directly proportional to the linear dimensions of the elements of the deposits, and inversely proportional to the slope.

In order to arrive at an idea of the comparative properties of rivers from the point of view of the fixity of the bed, we have collected samples of deposits from a number of streams, and to determine the average dimensions of their elements we have caused them to be passed successively through four sieves, of which the meshes were ¼, ⅛, 1/16 and 1/30 of a centimetre. In this manner each sample was divided into five portions, of which we knew the average dimensions, and by taking the weights of each of the portions, we were able to determine their relative proportions. The values of the dimensions thus obtained are given in Table IV. The slopes have been taken in part from the collection published by M. Tillo, and partly from other monographs, and this enables the character of each portion of the river to be given with reference to the average slope. By dividing the linear dimension of the elements of the deposit by the slope, we arrive at the figures given in the last column, which may serve as a measure of the relative fixity of the bed of the river.

According to the results thus obtained, the Vistula has the least stable bed, and then follow, in the order named, with increasing resistance, the western Bug, the Pina, the Pripet, the Dneiper and the Don; and even this last has a bed of very low resistance. The Volga shows a bed of much greater resistance, as indicated by the data already given, showing the deposits in the shallows during periods of high water; then follow in the same order, the Niemen, the western Dwina, and finally the most permanent, the Dneister.

As we have already stated, the more resistant the bed of a river, the more definitely the staircase form of profile appears, in consequence of the intermittent action of greater or lesser slopes, and because of the varying distribution according to the level of the surface of the water. On the contrary, the weaker the nature of the bed, the more uniform the slopes become, showing only partial oscillations and an uncertain form. It would be very instructive to be able to place the longitudinal profiles of the several rivers under consideration in parallel position for comparison, together with the coefficients of stability obtained as indicated in the table. Unfortunately, this is not practicable, since the data available for the slopes are very general in character and relate to various water-levels, the points having been taken almost haphazard, without system, in such a manner as to render it impossible to classify the slopes of portions having different characteristics. Under such conditions the profiles have a tendency to become uniform, and the local changes in slope, essential for our purpose, become indistinguishable.

We may, however, cite the longitudinal profile of the Dneister as characterising the properties of a river with a highly resistant bed, as already indicated by the description of its slopes on the curves, as well as the depths and shallows at high and low water. We have also cited the profile of the shallow "Teliatchi Brod," on the Volga, which shows very clearly the increase in the slope at low water, and its diminution during flood. Similar evidence appears in the profile of another portion of the Volga, near Poutchege, in which the record of high levels was prepared especially for this study, in 1893. In this portion of the river there are four shallows, those at Kosten, Yatchmen, Pestoff and Perelom, in which the current is very rapid at low water. The total fall is 9.10 feet in a length of 22.4 miles,

TABLE IV.

THE DETERMINATION OF THE FIXITY OF RIVERS BY THE COMPARISON OF THEIR AVERAGE SLOPES AND THE SIZES OF DEPOSITED MATERIAL.

Locality of Samples.		Weight in Grammes of Sediment Passing Sieves with Mesh of: $^1/_{30}$ mm.	$^1/_{16}$ mm.	$^1/_{12}$ mm.	$^1/_8$ mm.	Greater than $^1/_8$ mm.	Total Weight of Samples in Grammes.	Mean Diameter in mm.	Average Slope of the Portion of the River.	Ratio of Slope to Diameter of Sediment.
The Vistula	At Ivangorod	......	202.70	113.60	30.10	7.17	353.04	0.546	0.1475	3.70
	At Warsaw, rectified portion	......	130.07	97.40	83.80	52.87	355.79	0.617	......	4.18
	At Warsaw, rectified portion	......	148.17	83.20	96.80	64.13	392.30	0.621	......	4.21
The Western Bug	At Brest-Litovski	43.82	262.04	40.20	7.50	2.47	356.03	0.309	0.0770	4.01
The Pripet	At Pinsk	246.12	94.37	4.50	......	......	344.99	0.185	0.0310	5.96
	At the confluence of the Styr	272.42	55.17	......	......	......	327.59	0.171	0.0352	4.85
	At Mozyr	82.22	264.82	4.75	......	......	351.79	0.259	......	7.35
	At Tchernobyl, rectified portion	4.47	276.72	74.20	16.90	......	372.29	0.465	......	13.21
The Dnieper	At Glebovka	203.39	165.80	......	......	......	368.69	0.201	0.0415	4.84
	At Kieff, rectified portion	6.12	156.22	129.40	70.10	21.17	383.01	0.497	......	12.00
	At Kieff, rectified portion	5.39	190.21	113.40	46.90	16.97	372.87	0.488	......	11.75
	At Krementchoug, rectified portion	28.02	280.32	50.10	10.57	1.18	370.19	0.348	......	8.38
	At Ekaterinoslav	9.77	244.35	103.52	8.99	1.68	368.31	0.431	......	9.36
The Don	At the shallows of Kourmoiarsk	4.97	265.10	76.20	11 27	2.19	359.73	0.461	0.0318	14.49
	At the shallows of Kourmoiarsk	6.92	245.12	61.00	8.50	1.97	323.51	0.436	......	13.71
	At the shallows of Troilin	61.27	289.90	1.85	......	......	345.52	0.289	......	9.08
	At Rostoff on Don	38.37	262.90	23.65	5 27	13.67	343.86	0.317	......	9.97
The Oka	At Kolomna	......	44.47	147.75	132.90	35.97	361.09	0.735	0.0276	26.63
	At Kassimoff, beginning of shallows	......	61.97	207.00	89.30	11.37	369.64	0.680	......	24.63
	At Kassimoff, end of shallows	......	9.77	55.50	180.40	95.57	341.24	9.952	......	34.49
The Volga	At Yourivetz	......	145.17	145.46	67.10	24.77	382.50	0.602	0.0211	28.53
	At the shallows of Orekhoff	......	239.27	72.90	19.90	10.47	342.54	0.523	......	24.78
	At the shallows of Sokol	10.12	149.67	79.00	78.50	90.40	407.69	0.471	......	22.32
	At Yatchmenka, longitudinal dike	......	106.57	117.70	94.18	58.77	377.22	0.649	......	30.75
	At the shallows of Perelom	2.22	198.37	126.20	49.60	18.70	394.56	0.529	......	25.07
	At the shallows of Vetlansk	69.02	294.17	64.30	32.70	11.37	371.56	0.602	......	28.53
	At the shallows of Reviatsk	......	215.17	120.90	10.75	......	346.52	0.535	......	25.35
	At the shallows of Borsk, commencement	......	252.87	104.10	69.90	49.27	373.14	0.599	0.0253	23.67
	At the shallows of Borsk, ending	17.82	175.96	73.10	57.90	66.97	401.75	0.413	......	16.32
	At the shallows of Teliatchi, beginning	56.42	284.97	23.60	5.20	......	370.19	0.629	......	24.86
	At the shallows of Teliatchi, ending	......	216.77	116.50	29.85	13.67	376.79	0.550	......	21.73
	At the shallows of Teliatchi, new deposits	10.12	210.47	112.00	27.80	8.07	368.46	0.438	......	17.31
	At the shallows of Ourakoff, beginning	......	158.67	133.38	66.83	37.94	396.82	9.599	......	23.67
	At the shallows of Ourakoff, ending	41.74	306.67	4.68	......	......	353.09	0.310	......	12.25
The Niemen	At Grodno	......	......	......	......	......	......	7.000	0.1535	45.00
The Western Dvina	At Dvinsk	......	......	......	......	......	......	7.500	0.1254	60.00
	At Vitebsk	......	......	......	......	......	......	12.000	0.1254	96.00
The Dniester	At Soroki	......	......	......	......	......	......	15.600	0.0945	166.00

OBSERVATION.—The samples from rivers with sandy bottom have been taken entire; for the rivers Niemen, Western Dvina, and Dniester, with stony deposits, only the larger portions have been taken after separation from the fine sand and mud which in rivers of these types serves only to fill the holes, and does not affect the resistance of the bed. For the Dniester the analysis has been made from a large number of samples according to the method indicated in the text. As for the Niemen and the Dvina, the sizes of their deposits have been determined from only one or two samples, which might have been entirely accidental in character.

that is 0.40 foot per mile (the average slope of the entire section is 0.276 foot per mile); at high water this total fall is only 4.13 feet, a reduction of more than one and a half times, which corresponds to only 0.183 foot per mile. At the same time, for the five intermediate deep portions there is, at low water, a total fall of 3.15 feet upon a cumulative length of 21.6 miles, giving a slope of 0.145 foot per mile, while at high water this fall is increased to 6.44 feet, giving a mean slope of 0.296 foot per mile, or more than the average for the entire section.

These facts are in entire accordance with the conclusions drawn as to the fixity of the Volga. So far as rivers with beds of small resistance and varying beds are concerned, although detailed profiles are lacking, we believe that the fact of the uniformity of their slopes, together with the small variations from the mean slope, usually due to accidental causes, is clearly shown by such examples as the Vistula.

The engineers in charge of the rectification of this river have the intention of making an entire transformation in its profile, giving it the regular form of a parabola.

Another conclusion to be drawn from the table is the appreciable increase in fixity of the bed at points where rectification works have been executed. Thus, on the Vistula, at Ivangorod, where the river remains in its natural condition, the coefficient of fixity is equal to 3.70; at Warsaw, where improvement works have been executed, it rises to 4.20. On the Dnieper at Glebvoka the coefficient is only 4.84, while in the vicinity of improvement works it is 8.38 at Krementchoug, 9.36 at Ekaterinoslav, and 12.0 at Kieff. In the same manner the Pripet, in its natural state at Pina, has a coefficient of 5.96, and at Mozyr 7.35, while in the improved section at Tchernobyl the coefficient rises to 13.21. It is evident that the contraction of the bed causes the removal of the finer portions of the material, while the larger particles remain behind, and this fact is also demonstrated by the examination of the selected samples. We may note that in general the elements of a deposit are of different dimensions, according as they are found in tranquil or rapid waters. Thus samples may be taken from different portions of the same sand-bar, beginning at the head, situated in the direction of the current and ending at the tail-end, where the water leaves it. Such a series of samples will exhibit very clearly the gradual transition from the coarse particles at the beginning to the fine sand and mud at the end. But the point in which we are especially interested is the resistance of the bed to the destructive force of the water, determined by its physical constiution; it is the deposits of the coarser material which characterise one or another river, and not the finer matter and mud. We make this remark because it is only from samples selected with this precaution which furnish information of value for the comparison of the stability of different rivers; besides this it is necessary that samples should be collected in sufficient quantity to enable the particular character of the deposits of a river to be determined with proper degree of precision.

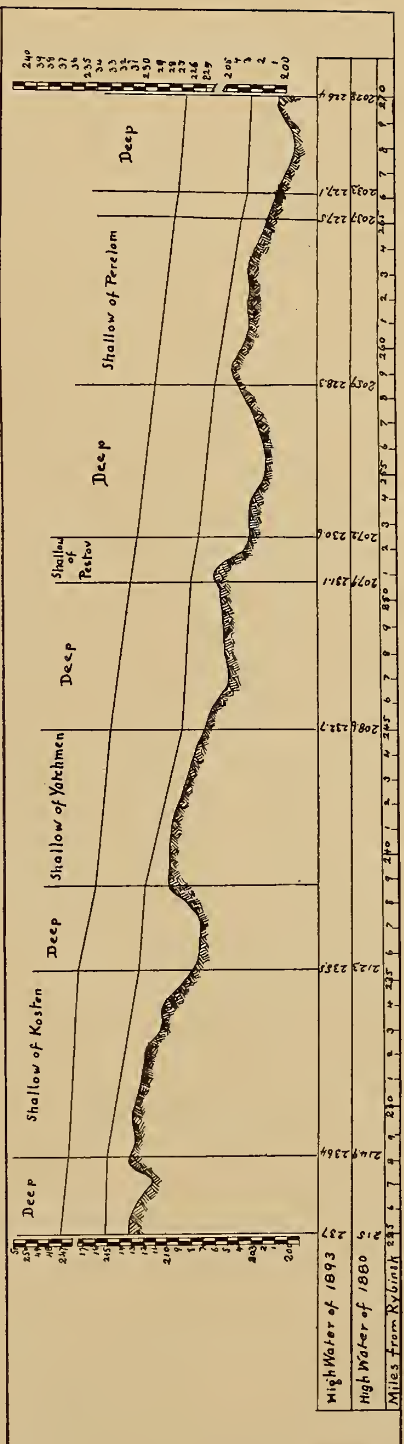
For this reason the accompanying table for coefficients of fixity of certain rivers must not be accepted as finally determinate, as we were not able to secure a sufficiently large number of samples to secure this. In publishing it as an example we may observe, however, that the method possesses great simplicity, and that it is most desirable that specialists engaged in work upon various rivers should collect the material necessary for further research.

We have indicated the method of finding the coefficient of fixity of a river, but we may also remark that the relation between the size of the elements of the deposit and the slope of the stream does not exhaust all the conditions.

The bed of a stream consists, not only of a bottom, covered with deposit, but also of the banks, and their resistance exerts a greater or less influence upon the relative permanence. It would be very interesting to introduce this factor into the coefficient of fixity, comparing the relative resistance of the layers of which the banks are composed, but the absence of observations upon this subject renders this impossible. Another circumstance which doubtless plays an important part in the phenomena of the changes in river beds is the duration of the action of strong currents; it is evident that the action of a current during a period of fifteen days in one case and two months in another must be different for the two cases.

There is also a considerable influence in the manner in which floods are formed, as well as in the relation between the kinetic energy of the high and low waters, besides the formation and movement of ice, the condition of the banks, and a number of other elements, which we have been compelled to omit in comparing the permanence of various rivers. Each of these factors naturally bears its part in influencing the natural condition of rivers, complicating the character and rendering the distinctive characteristics the resultant of the action of a number of causes. However this may be, in the united action of these diverse causes, the constant and preponderating influences are those of the slope of the river and the properties of the material of which the bed is composed. As we have already seen, it is the relation between these two factors which determines the position of any river among others, giving it its distinctive properties.

Without considering further the conditions which complicate the phenomena indicated, we will close with some general conclusions drawn from the theory set forth from the point of view of the possible improvement of water courses.



LONGITUDINAL PROFILE OF THE VOLGA NEAR THE TOWN OF POUTCHEGE

It is well understood that the contraction of the width of a river has the effect of deepening the bed. For this reason the portion to be deepened is walled in by a system of dikes, reducing the width of the current and increasing the velocity by reason of the holding back of the water above. The current thus produced scours up the material deposited between the dikes and carries it further downstream, thus producing a deepening of the bed. If the river belongs to the type having a resistant bed, in which the works have been executed along a shallow portion, and if the improvements are continued far enough down, the material picked up by the current will be carried along and deposited in the next deep portion, where the stronger slope at the following period of high water will produce the natural entrainment of these deposits, according to the mutual action of shallows and depths which we have already explained. But if the river belongs to the wandering type, which, because of the slope being too strong for the bed, does not possess clearly defined deep and shallow portions, the deposits formed immediately below the works will not coincide with any natural reinforcement of the slope, and because their moderate prominence is unable to produce the reaction necessary to reinforce the current, they will remain in position. Thus the effect of the works will be merely the displacement of the bar to a point lower down the stream. It will then be necessary to continue the improvements still further down, and thus keep the deposits moving along until the whole portion of the river under consideration has been included. Of the two essential factors of such a river, its slope and the resistance of its bed, the former has a much stronger influence than the latter, and one which it is absolutely impossible to change; the engineer is therefore able to adopt only one method to obtain a more favorable state of equilibrium, the increase in the resistance of the bed. This is accomplished by providing artificial banks of high resistance, and by encouraging, by an increase in the velocity of the water, the removal of the softer deposits, leaving the coarser portions behind. These facts are proved by the notable increase in the values of the coefficients of fixity in the improved portions of the rivers in the table.

A complete change in the nature of the river; reduction as much as possible in the influence of the excessive slope for the bed, by rendering it absolutely uniform throughout the entire length of the stream without local increase above this mean; that is, the production of the minimum possible slope on the one part, and the artificial increase in the resistance of the bed over its entire length on the other part, these are the logical conclusions which follow a rational investigaion of the possible amelioration of the wandering type, and it is under this form that further applications should be made.

Let us pass to the case of a river possessed of permanence, due to the resistance of the material of which its bed is composed, and to its moderate slope. We will suppose that the same method of improvement is applied to a river of this type, and that it has been so modified along its entire course that it has been given a regular profile and a normal width. A river thus improved will no longer maintain its tranquil depths nor its rapid shallows, nor the staircase form of profile, with its succession of large and small slopes; the entire bed will have the character of a uniform canal, of uniform width, uniform mean slope, and of uniform velocity of current.

But we have already observed that the distinctive character of a river with resistant bed lies in its division into sections having alternate steep and moderate slopes, this being the indispensable condition of equilibrium between the motive power of the water and the resistance of the de-

posits. We have also seen that the deposits on the shallows were the result of the action of high water, which, at certain localities, in consequence of various causes, mostly inalterable and dependent upon geographical conditions, became retarded in movement and encouraged the settling of the material, until it was again loosened and moved on by the swifter current at low water. It thus appears that shallows are indispensable instruments in the work of entrainment of deposits, and that the steep slopes of low water are the only methods by which the work is accomplished. If, then, we suppress these shallows with their rapid currents, and produce a uniform bed with its uniform velocity, corresponding with the average slope, this velocity, giving the mean and constant action along the whole course of the stream, will be much inferior to that which the river formerly possessed, and which was proportioned to the resistance of the deposits. The current will thus be unable to carry on down the stream the material deposited each time by the high waters, and it will necessarily accumulate in the vicinity of the former shallows, and thus, little by little, the former profile of the river will be re-established. Let us recall the data and slopes and velocities of current in the example of a river with a resistant bed, the Dniester. In its present condition there exists in the shallows velocities of current of 5 to 7 feet per second, and even with these velocities the bottom, which consists of coarse gravel, remains in invariable condition, neither deepening nor filling up; we thus conclude that these values of velocity and slope are indispensable for a bed of this character. If now, we should give the Dniester, throughout its whole course, the uniform mean slope of 0.000289, the velocity of the current would fall to less than 2 feet per second. It is evident that with such a bed, and with deposits requiring velocities of 5 to 7 feet for their displacement, a current of not more than 2 feet per second would not suffice to maintain a durable bed, and the river would gradually revert to its former condition.

This reasoning proves that while the method of improvement of a channel along its entire length is the rational and only practical one for a river with a wandering bed, it is inapplicable and even injurious in the opposite case of a stream with a resistant bed.

The conservation of equilibrium established by Nature, by means of the division of the work of entrainment of deposits between periods of high and low water; the study of longitudinal profiles corresponding to different levels of water; the classificatio of rivers into sections with reinforced slope during periods of high water, in which the bed is consequently free from obstructions and which would remain after improvement in their natural state, and into sections of lower slope during the same period, in which the bed is subject to the accumulation of deposits; the study of the mechanism of each shallow, so far as concerns the provision of energy stored up for use during low water, and the use made of it; the study of the disposition of sand-bars and of currents; and, finally, the most rational and economical utilization of the kinetic energy and the corresponding rectification of the length of the bed included between two depths situated above and below a shallow; these are the elements of a proper method for determining the solution of the problem of the improvement of rivers of this type.

We shall not enter into the details of this subject; they belong rather to a treatise upon the special art of improvement of river beds, and we shall confine ourselves to a few remarks directly suggested by the ideas above mentioned. We have already said that if, in executing improvement works upon a shallow in a river of the type having a fixed bed, the works are pushed down to the

junction with the lower depth, the accumulated velocity produced at this point during high water will move the deposits which the current at low water had displaced beyond the shallows. It thus appears that, according to the mechanical conditions of the movement of water alone in a given channel, the limit of extension of improvement works should be controlled by the length of the shallow, so that they should not reach the following deep portion.

In actual practice, if a permanent deepening of a certain amount is to be obtained, it must not be forgotten that the removal of deposits from the shallows during low water requires a certain amount of time, and if this is not given the deposits may accumulate and bar the navigable channel. The fact is known that shallows become unnavigable when the level of the water falls very rapidly after a flood, while, on the contrary, a slow falling of the water-level produces an arrangement of deposits favourable to navigation. If, however, we change artificially the natural conditions of a shallow, and increase the velocity of the current at low water, we increase the force which acts to entrain the deposits down the stream to points below the limit of the shallow; we thus increase the possibility of their temporary accumulation at the transition point between the shallow and the following deep portion. If the portion thus situated in the immediate vicinity of the shallow is very deep, the material thus brought down will find a lodging-place without interfering with navigation. This fact explains the satisfactory results which sometimes follow improvement works of this kind. But if the passage from the shallow to the deep portion is not abrupt, but has a sort of transition character, the deposits coming down with force from the improved shallow may obstruct this intermediate portion of the bed, and necessitate a still further extension of the works.

Occurrences of this kind, frequent enough in practice, have given rise to doubts among engineers as to the possibility of the improvement of a limited portion of a river, whatever be its character, and have had much to do with the application to rivers of all kinds of the method of improvement along the entire length, without considering the contradictions which are sometimes involved.

However this may be, it logically follows, from a consideration of the phenomena of the movement of water and the deposits of solid material, as well as from the facts observed in connection with practical improvement works, that the most delicate point to be considered in deepening the bed lies in the portion connecting the lower part of the shallow with the upper part of the following depth. In order to avoid misunderstandings, it is necessary to give some attention to this point. In this case it is desirable to utilise to the best possible advantage the current existing during low-water in connection with the natural slope corresponding to that period; we thus enter into the field of considerations upon the correlation existing between the secondary beds of rivers and the conditions of uniform movement, a study which is rich in varied and numerous investigations. These studies, incapable of serving in the investigation of the character of a river as a whole, demanding broader and more powerful factors and concerned with the non-uniform movement of the water, are far from being useless so far as the minor bed is concerned; they prove that it is the uniform movement alone, with an action sufficiently prolonged, which gives a definite form to a river. In fact, as the longitudinal slopes, with their variations depending upon the level of the water, produce the described effects upon the longitudinal currents, they form at certain points (according to the general plan of the stream) transverse slopes, due to the inertia of the masses of water in

movement, and these again cause transverse currents, independently of the regular or irregular condition of the river. As we have already indicated, these phenomena appear upon curves, along which, due to the reaction due to the concave bank and the pressure of the water which is there elevated, the liquid masses descend toward the bottom, driving the lower layers over toward the convex bank, as a resultant of the longitudinal transverse movements. There is thus produced in the water a current having a permanent helicoidal movement which transfers the deposits from the bottom of the concave bank to the convex shore, similar to the action seen on a smaller scale by the action of a whirlpool upon a bed of sand. The result is the production of a deep channel along the concave bank and a corresponding bar on the opposite side of the river, a fact which repeats itself at every turn of the stream.

It is phenomena of currents of this sort, discussed analytically by the French engineers MM. Fargue and Dubois and others, which are used in connection with what may be called the normal width, to lay out new lines for the banks of a stream for improvement.

These are, however, far from including all the causes determining the condition of a river bed, and very often they are wholly unavailable.

They, therefore, do not prevent some of the disagreeable surprises which sometimes follow the execution of rectification works, especially if these have not been made with due attention to the natural properties of the river. Being correct, however, for the movement of the current at low water, they serve to furnish the necessary data in connection with the utilisation of the low-water currents in producing the desired depth. We shall not repeat the points emphasised by the French engineers with so much ability, with regard to the plan of a rectified stream; we must return to the question indicated above, of the importance of the possible obstruction of the critical point of the passage from the shallow to the following deeper portion. We may remark that to avoid shoaling up at this point, it is necessary to make the junction between the shallow of the following depth of a concave form, either by the use of the natural banks, or by the construction of concave jetties or dikes, these producing, as experience has demonstrated, a deep channel at their base, the reaction being sometimes so powerful as to require the jetty to be strengthened against destruction. The connection with a concave curve being executed, there is added to the periodical entrainment of the deposits a continuous transverse entrainment, so that the material deposited during the temporary retardations accumulates against the convex bank without obstructing the channel on the concave side. By a rational arrangement of curves it is thus possible to maintain a satisfactory depth in the connection between the shallow and the following depth.

We shall go no further into the subject of the improvement of shallows—this lies in the domain of the hydraulic engineer. We have limited our problem to the consideration of general facts; and we repeat, before closing, that it is only by experimental investigations conducted according to a uniform programme (investigations so rare as to be entirely lacking in many cases) that we may be able to make the comparisons necessary to judge the extent to which the ideas here expressed are in harmonious accord with the diverse phenomena of the currents of rivers of different types.

Fewer formulas and more observations; this is the demand which the student of the actual behaviour of rivers makes of the specialists in the interest of true development

CONVEYORS

By Henry J. Edsall

IT is doubtful whether many people, not directly interested, have ever stopped to consider what an important part conveyors play in the trade and activities of the present day. They may, in some of their travels, have noticed a little stone elevator handling stone from a crusher to an overhead bin, from which it can be rapidly loaded to wagons by means of chutes. Or, possibly, they have seen a conveyor equipment, at some electric power station, handling coal to a bin above the boilers, from whence it feeds automatically to the mechanically-operated stokers, and then on into the furnace to supply the energy to light our houses and move our street cars. In most cases, however, conveying machinery is buried in the depths of some manufacturing plant, or is in some out-of-the-way place, where the average person would not dream of its existence.

This is an age of large and varied enterprises, and the products of mine, farm and forest have to be handled to cars or boats at the shipping point, unloaded and handled again at the receiving or transfer point, and, possibly, handled many times and in varied forms through the processes of a manufacturing plant.

Therefore when we consider the enormous quantities of bulk materials and the endless number of barrels, boxes and other packages which have to be handled from one place to another every day, we begin to realize what possibilities there are for reducing the costs of handling by using machinery instead of manual labor.

In the Century Dictionary we find the word conveyor defined as: "One who or that which conveys, carries, transports, or transfers from one person or place to another." This would apply to almost any kind of a carrier, from a man with a wheelbarrow to a modern coal-handling outfit, but, as a rule, the term conveyor is now used to describe those machines which move at a constant speed and convey continuously in a given direction. They don't stop and go back for another load, but keep the material moving forward all the time, so that bulk materials are conveyed in a continuous stream, and packages are handled one after another at close and regular intervals.

Thus, though the stream may be small, or the speed of the package carrier low, the fact that the operation is continuous makes the carrying capacity large. A comparatively small conveyer will, therefore, more than keep up with a car or platform elevator, operating intermittently, especially if the car has to go back very far for its next load. In addition to this the conveyor can be arranged so that it is necessary only to feed the material to it and it will be automatically discharged at the desired point. The power consumed is also likely to be considerably less than with the car or platform elevator since, when it is used for elevating, the lifting side of a conveyor is balanced by the return run and the only power necessary is the amount required for lifting the weight of the material and overcoming friction.

The conveyors which are most used at the present time may be di-

AN INCLINED CONVEYOR FOR COAL. LINK-BELT COMPANY, PHILADELPHIA

vided into the three general classes, of chain conveyors, screw conveyors and belt conveyors. The general use of chain conveyors started with the invention of the Ewart malleable iron link belt patented by Mr. William D. Ewart in 1873. As shown in the illustration, it consists of one-piece links of a proper width to give stability and bearing surface in the joints, and in the contact with the sprocket wheels. It has hook and bar joints, and the links may be detached by simply turning two adjoining links to a certain angle and slipping out sideways. This chain proved an excellent power transmitting device for slow or moderate speeds, its cost being low enough to insure its wide use commercially.

It was not long before the possibility of using chains in other ways occurred to people. Wings, called attachments, were cast on some of the links and buckets bolted to an endless chain running over sprocket wheels, one above the other, the buckets picking up grain or other material at the lower end, carrying it up and discharging it at the upper end. This was the beginning of the various types of chain and bucket elevators. For conveying horizontally or on an incline, other attachments were designed, to which scrapers or, technically, flights were attached. As the chain moved along these flights pushed the material along in a metal or wooden trough, from which it was discharged either over the end or through doors or gates in the bottom.

MODERN COAL HANDLING IN AN IRON WORKS. LINK-BELT COMPANY, PHILADELPHIA

Various types of bucket elevators are used at the present time, depending on the material handled and the kind of service. In some cases the buckets pick up the material from a boat, and in others it is delivered directly into them. Likewise, some elevators depend on the centrifugal force to throw the material out of the buckets as they pass around the head wheel, and in others the matreial slides from one bucket over the back of the one ahead, the buckets being continuous, or else the direction of travel of the buckets is changed so that the material drops out by gravity. Sometimes the buckets are pivoted, so they can be tilted, or the bottom arranged to drop down and let the material fall out.

The centrifugal discharge and continuous bucket elevators ordinarily employ only one chain, unless the service is heavy, but the other types usually have two. The elevators with pivoted buckets and others which carry the material along horizontally or on an incline, are termed carriers, and these machines frequently follow a path with several changes of direction. Such machines usually have the buckets arranged so that when traveling horizontally they are continuous, that is with little or no gaps between, and in some cases each bucket has a lip which laps over the edge of the next bucket to avoid spilling material between them when they are being loaded. The chains of the carrier are of heavy flat links of malleable iron or steel and have rollers at the joints which, on horizontal or inclined runs, travel on steel tracks and support the buckets and chain.

Flight conveyors are made with either one or two chains and various shapes and sizes of flights. Sometimes the flights slide on the trough, and sometimes they are supported above the trough by sliding or rolling the chain along on tracks at the side, or by separate slides or rollers at each side.

Screw conveyors have a central shaft to which is attached a spiral blade, this blade revolving with the shaft and pushing the material along parallel to it. A trough is usually provided of steel, wood or concrete, though the material which is being conveyed is sometimes allowed to pile up around the screw and form its own trough. Screw conveyors are simple and not very expensive, and are largely used in manufacturing plants and in handling grain, but they are suitable only for handling certain kinds of materials, and will

HUNT COAL AND ASH CONVEYOR AT WORKS OF B. F. GOODRICH COMPANY, AKRON, OHIO

not satisfactorily handle coarse, sticky or very abrasive materials, the latter tending to wear them out rapidly.

Belt conveyors consist essentially of a belt running over pulleys at each end and supported on idlers at intermediate points. Where bulk materials are to be handled the idlers on the conveying run are usually designed so that they trough or bend the belt to a concave form to make it hold more material, without spilling it over the edge. This is accomplished either by making the idler roller with a concave curve or using more than one roller and placing at least two of them on an incline so

HOW MATERIAL WAS HANDLED BEFORE MODERN CONVEYING MACHINERY CAME INTO USE

as to bend up the outer edges of the belt. A belt conveyor can be run at a comparatively high speed with correspondingly high rate of handling, and it will handle abrasive materials without undue wear, since the material rides along on the belt, as it does in the buckets of a carrier, and there is no sliding, as with a flight or screw conveyor. Belt conveyors are, therefore, admirably adapted to certain conditions, but they are rather an expensive type of conveyor and, in many cases, cost more to maintain than some other types. They also have the objection of being rather cumbersome to discharge from, except over the end.

The uses for conveyors are almost unlimited. First of all comes the handling of coal. Starting at an anthracite mine we find that it is often not convenient to run the cars to the head of the breaker. In such a case they are dumped on a tipple at the mouth of the shaft and the coal feeds to a flight conveyor or bucket carrier, running up on a long incline, and delivering coal, possibly at the rate of 500 tons per hour, at the head of the breaker. From here it passes down through a system of crushers, screens and washers until it comes out at the bottom into railroad cars as egg, stove, nut and so on.

At some West Virginia soft coal mines conditions may be reversed, the mouth of the mine being up on a hillside and the railroad down in the valley. Here a retarding flight conveyor holds the coal back so that it will not slide down the trough with a rush, and as the preparation and separation into different sizes is probably omitted, it goes direct to railroad cars and is shipped as run-of-mine coal. These and many other problems at the mines are solved with conveyors.

When the coal is shipped from the mines much of it goes direct to the consumer or the retail dealer, but when the supply exceeds the demand part of the coal is put into storage to remain until needed, later on. This storage also serves as a source of supply in case of strikes. With sized

THE DODGE SYSTEM OF COAL STORAGE FOR ANTHRACITE

anthracite coal, which is easily handled, and can be piled to almost any depth, conveyors are the simplest and most economical method of handling into and out of storage. The "Dodge" system is the one most used, since it is comparatively cheap in first cost and very economical in handling the coal, the cost of handling from cars to storage pile and back to cars again being less than three cents per ton. With this system two light steel trusses are set at an angle with the ground so that they come together at the top, like the timbers of a peaked roof. These trusses are braced against wind pressure by means of guy ropes and the one on the side towards the railroad track is fitted with a flight conveyor, with a track hopper at the foot. In this case the bottom of the conveyor trough is formed by means of a steel ribbon, which winds upon a drum at the foot, so that the trough bottom can be made to end at any desired point on the truss. The coal is delivered from the bottom-dump cars through the track hopper to the foot of the conveyor, which discharges it over the end of the ribbon bottom. In this way the coal is discharged from the conveyor close to the ground, when the pile is started, and the discharging point moved up as the pile increases, so that there is practically no drop and, therefore, no breakage. Conical piles are formed under these trusses, each pile containing, in some cases, 60,000 tons of coal.

These piles are placed in pairs so that when full they almost come together at the ground level, and a reloader is placed between them and arranged to swing either way over the area covered. This reloader consists of a flight conveyor, with the chain traveling in a horizontal plane, and the whole conveyor supported on wheels traveling on circular tracks and pivoted back near the railroad track. When it is desired to reload the coal from the pile the operator starts the conveyor and then, by means of a mechanism controlled by levers, swings it against the pile. The flights slide along on a steel trough, with an open side towards the pile, and as they come into con-

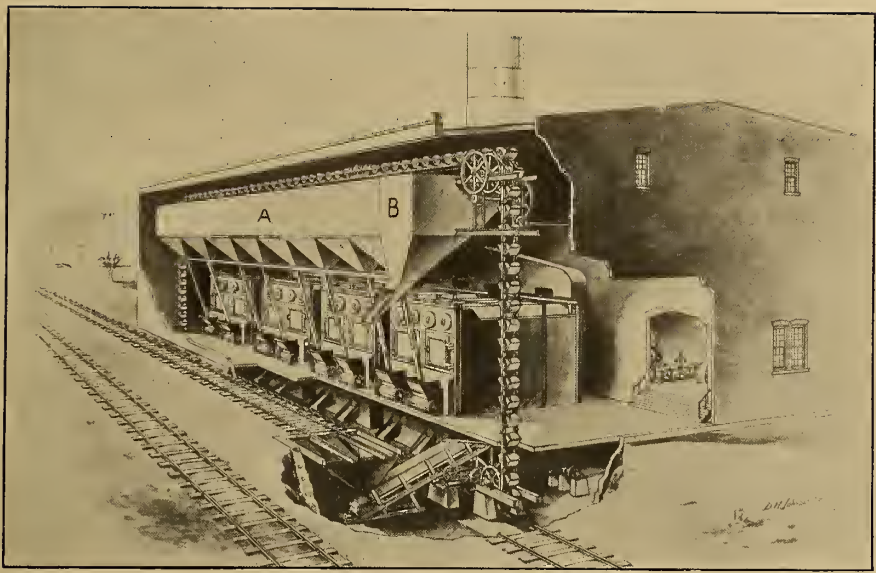
CONVEYOR DELIVERING COAL INTO BINS AT THE WORKS OF THE MORGAN & WRIGHT COMPANY, DETROIT.
C. W. HUNT COMPANY, NEW YORK

tact with the coal they push it along to the pivot point, then up an incline, and it is discharged over screen chutes back into the railroad cars. The largest plant of this kind now in existence has a total storage capacity of nearly 500,000 tons.

As soft coal is usually shipped as run-of-mine and contains large lumps, it cannot be satisfactorily handled in this way. Besides this, it is not safe to store it too deep for fear of spontaneous combustion. On this account, when soft coal is to be stored in large quantities it is usually best handled by means of a self-filling bucket holding a ton or more. Sometimes a revolving locomotive crane is used to hoist the bucket and swing it around so as to distribute the coal in a shallow pile covering a large area, and at other times the bucket travels back and forth on an elevated bridge which either swings around a central pivot point or travels along on parallel rails. The bucket also picks the coal up from the storage pile and takes it back to railroad cars or vessels or delivers it to a hopper from which it feeds to a conveyor.

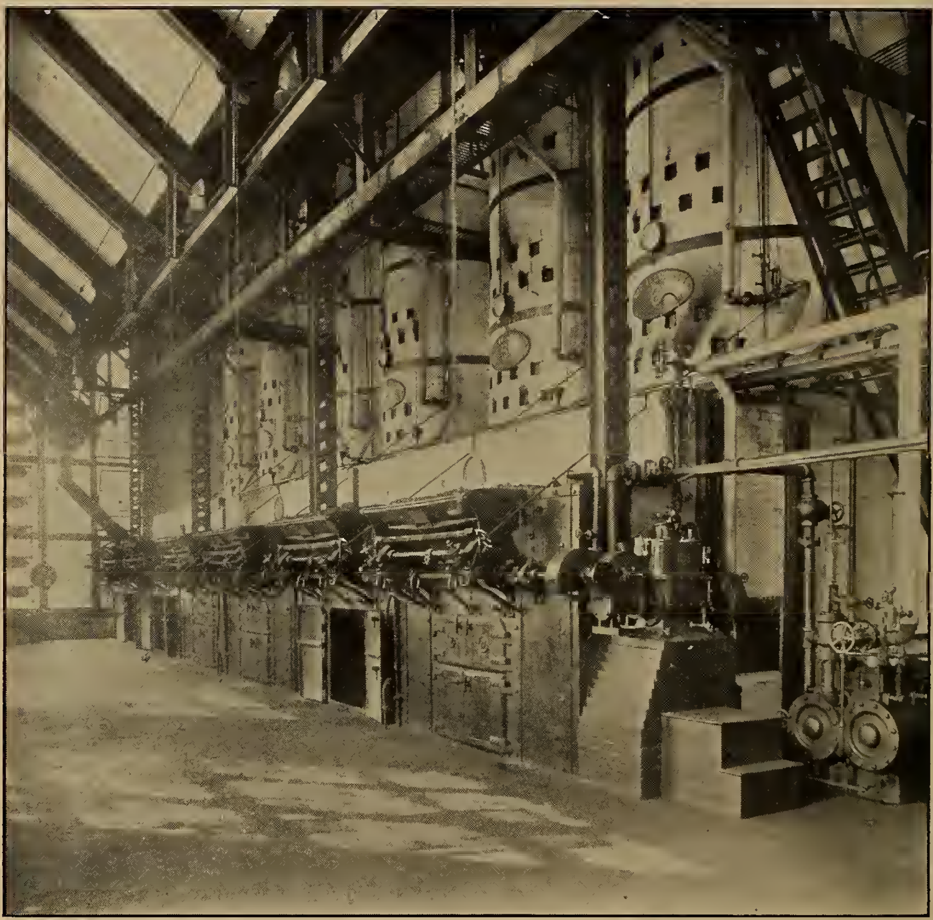
Storage is a very important consideration in these days, when any interruption to the fuel supply is such a serious matter, and besides the railroads and coal companies, many electric companies, gas companies and other large consumers, have their own outside storage plants of a capacity to last several months. This not only insures them against strikes and interruption to railroad traffic, but enables them to take advantage of low prices at certain seasons of the year, and thereby save considerable money in buying coal.

At the end of the journey coal



A CONVEYOR SYSTEM FOR BOILER HOUSE. LINK-BELT COMPANY, PHILADELPHIA

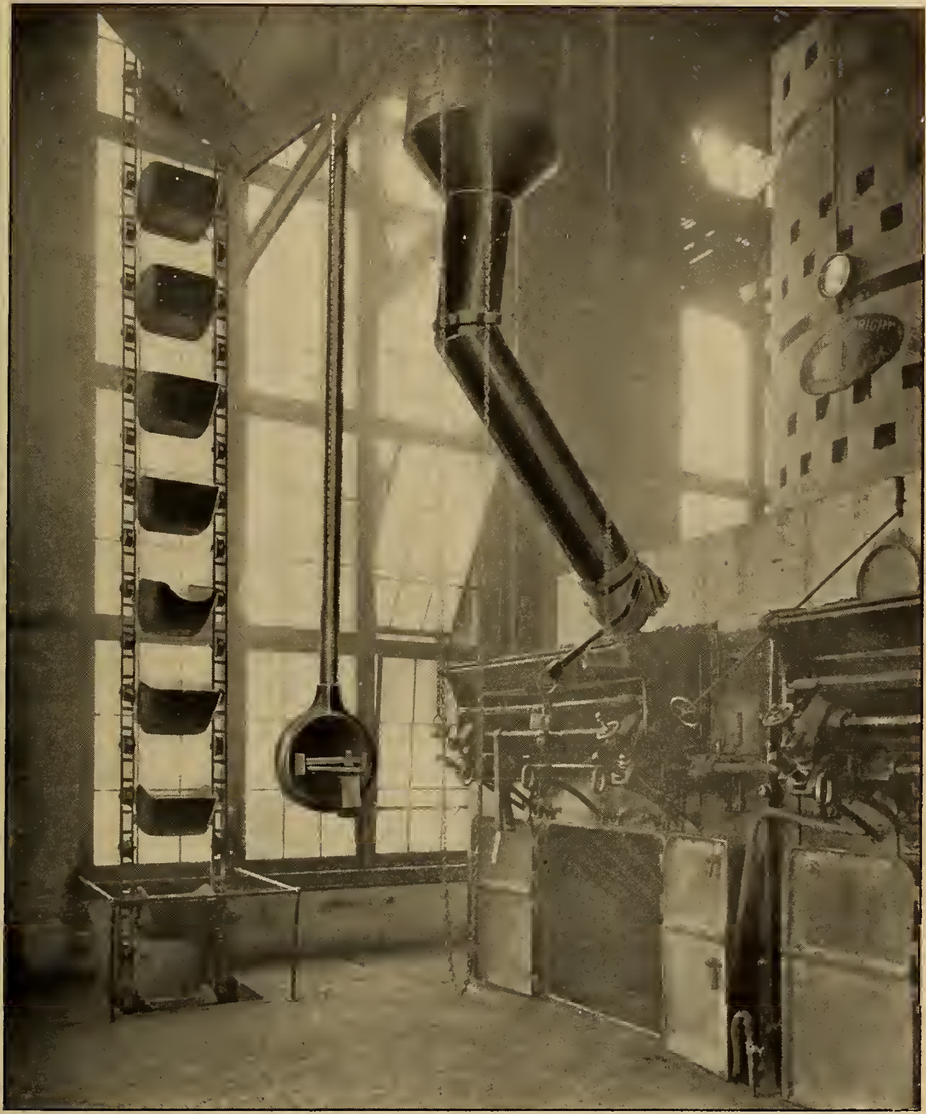
LOCAL COAL STORAGE BIN. LINK-BELT COMPANY, PHILADELPHIA



MORGAN & WRIGHT BOILER ROOMS, SHOWING HUNT CONVEYOR IN DISTANCE, ALSO TRAVELING CHUTE TO FEED AUTOMATIC STOKERS

either goes direct to the consumer or to a dealer for further distribution. The large consumers are the railroads, electric power plants, gas and coke works, and manufacturing plants. The dealer sells the domestic sizes to householders for use in their houses and the steam sizes to public buildings, office buildings, manufacturing plants and other places for generating steam.

In any case it is necessary to unload it from the cars and either cart it away at once or handle it to some form of storage or bin. If it is shoveled from the cars by hand it costs, as a rule, from eight to ten cents per ton, while if it is dumped through the bottom of the cars into a pit underneath the track and delivered to the pile or bin with conveyors, it can ordinarily be handled for about three or four cents per ton, and sometimes less. Where considerable coal is handled this is quite an inducement, and money invested in coal handling machinery usually pays a good return on the investment. An additional and even greater advantage obtained by the use of conveyors in unloading cars is the possibility of placing the coal where most convenient, so that little further expense will be necessary in subsequent handling. In a boiler-room, where mechanical stokers are



END OF BOILER ROOM, MORGAN & WRIGHT WORKS, SHOWING HUNT BUCKET CONVEYOR AND MOVABLE HOPPER

used, it can be placed in an overhead bin, from which it will feed by gravity direct to the stokers, so that it need not be handled at all by hand.

In some of the large power houses these bins hold several thousand tons, one of the power houses which supplies power to the electric railways in New York City having a bin with a capacity of 15,000 tons.

Where the stoking is done by hand it can be stored overhead or in front of the boilers, so that it will feed to the boiler-room floor, within easy reach of the firemen. For a small boiler-room a simple chain and bucket elevator or inclined conveyor often suffices for transferring the coal from cars to bins. The foot of the elevator is placed in a pit underneath the track, and the coal feeds to it from the bottom of the car

A MODERN FURNACE HOIST. BROWN HOISTING MACHINERY COMPANY, CLEVELAND, OHIO

through an intermediate track hopper, with a gate to regulate the flow. Where the bin is of some length, a distributing conveyor is placed over it with various discharge points along its length. For small-sized coal a screw conveyor is sometimes used, and for larger coal either a flight or belt conveyor.

Run-of-mine bituminous coal containing large lumps is often crushed before delivering to the bins, especially where mechanical stokers are used. A crusher, with revolving-toothed rolls, is placed close to the track hopper and some form of automatic feeder is used to feed the coal from the track hopper to the

A BROWN HOIST BRIDGE TRAMWAY AT REPUBLIC IRON & STEEL COMPANY, HAZLETON, OHIO

C. W. HUNT CONVEYOR AT WORKS OF THE B. F. GOODRICH COMPANY, AKRON, OHIO

crusher at a regular and suitable rate. Where only a small amount is handled the large lumps are sometimes disposed of by breaking them by hand on a grating placed over the track hopper, this grating having openings large enough to allow all except the large lumps to pass through.

Instead of using one machine for elevating and a second machine for distributing the coal in the bins, these two operations are often accomplished by a single machine, either of the gravity discharge or pivoted bucket type. The latter type is also a good one for handling ashes, so that both coal and ashes can be handled by the same machine. With such an arrangement the upper run of the carrier travels over the bin and the lower run in a tunnel or basement underneath or in front of the ash pits, so that the ashes can be fed to it with little labor. Frequently, however, a separate ash-handling outfit is installed, either a separate carrier which both conveys horizontally and elevates, or a conveyor or car for conveying horizontally and a chain and bucket elevator, or a so-called "skip hoist," that is a single large bucket and cable hoist for delivering the ashes to an overhead bin, from which they can be drawn out to carts or railroad cars or boats.

Machinery for handling ashes has to be designed with due regard to their abrasive nature and it also, as a rule, has to stand the corrosive action of the water used in quenching them, this water becoming slightly acid on contact with the ashes. This is a very severe service for any machinery, and while a simple elevator can be made quite durable without being excessively expensive, a carrier is about the only satisfactory type of horizontal conveyor for ashes, aside from a car, and a good carrier is quite expensive. Sometimes a

A HALF MILE OF ORE AND COKE BINS BUILT FOR INDIANA STEEL COMPANY, GARY, IND., BY THE BROWN HOISTING MACHINERY COMPANY

VIEW BENEATH THE GARY ORE AND COKE BINS

TRACK PIT AT WORKS OF MORGAN & WRIGHT, DETROIT. C. W. HUNT COMPANY, NEW YORK

wide malleable iron chain is used without any attachments, the chain itself pushing the ashes along in a concrete or cast-iron trough. With such a chain moving very slowly the life is fairly long, and it is not very expensive to replace when worn out. A system devised recently uses air pressure to blow the ashes along dry, and they are sprayed as they are delivered to the bin.

At gas plants and coke oven plants the coal is handled in much the same manner as at steam plants. At the coke oven plants a larry or charging car receives its coal from an overhead bin and delivers it to the ovens. At retort and generator houses and producer plants a charging machine or traveling hopper acts as the intermediary between the overhead bin and the retort or generator, or in the smaller plants the coal is sometimes delivered to the charging floor and then shoveled by hand. At the gas and coke plants there is also the

problem of handling the coke which, on account of its abrasive nature, is usually handled on a belt conveyor, or by some form of carrier.

When coal is to be used by a railroad for coaling engines it is usually placed in overhead pockets, so that it can be delivered by gravity to the tenders. This is accomplished either by running the cars upon a trestle and directly over the pockets, or by transferring from the cars to the pockets by machinery. The latter arrangement requires much less ground space, can be fitted to almost any arrangement of tracks, and is usually cheaper in first cost and also in operating and maintenance costs when the interest on the investment is taken into consideration. The locomotive ashes or cinders are dumped into pits and handled to an overhead bin by a carrier, or dumped into tubs placed in pits between the rails, and the tubs then hoisted by a cable hoist and dumped into an overhead bin, or sometimes direct to cars.

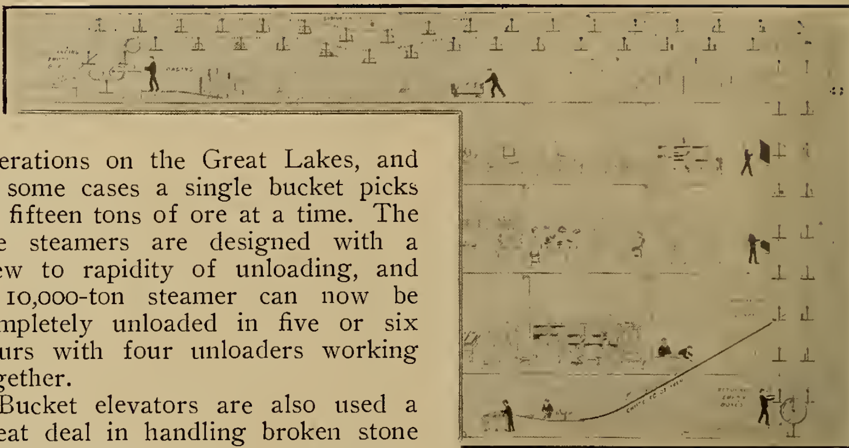
At retail coal yards a mechanical equipment is especially valuable. The cars are handled on a ground level siding with a pit and track hopper at one point. After placing a car over the pit the machinery is started, the doors in the bottom of the car opened and the coal flows into the track hopper and down to the foot of the elevator, the rate of flow being regulated by means of a gate or automatic feeder. The elevator buckets carry the coal up to the desired level where, as a rule, it is delivered to a distributing flight conveyor, which conveys it along the top of the pocket, and by means of the discharge gates, it is delivered to its special bin, according to its size. Sometimes a single machine of either the gravity discharge or pivoted bucket type does both the elevating and conveying. The machinery is driven by means of an electric motor or gas or steam engine, and about the only labor necessary is to start the motor or engine, open the gate where the coal is to be discharged and open the car doors. With the hoppered steel cars practically all the coal will flow out without help, but with wooden cars, with part of the bottom flat, there is some shoveling necessary to clean out the car completely. These outfits usually handle from 30 to 50 tons per hour, and the machinery is simple, and not very expensive.

After the coal is placed in the overhead bin it can be drawn out to the wagons by gravity. This not only saves the labor of shoveling the coal to the wagons and the inevitable delays to the teams, but it also saves one operation, that of screening the coal, for the chutes which deliver to the wagons can be fitted with wire screen bottoms, so that the coal is screened as it flows over them.

The overhead pockets are usually built of wood and partitioned off into the required number of bins. Of late, concrete has been used to a considerable extent. This makes a fireproof building, and one which requires little or no expense for maintenance.

Where coal is received by water the boat unloading is generally accomplished by means of a single self-filling grab bucket and hoisting rig, after which it may be handled by means of conveyors or some sort of car system. A chain and bucket elevator is sometimes used for unloading boats, the foot of the machine being lowered into the coal and the buckets dipping it up as they pass around the foot wheel, but this type of machine is not suitable for large lump coal.

In plants for crushing, separating and treating ores, conveyors play an important part. Bucket elevators and belt conveyors are the usual types employed and they handle the ore from crushers to storage bins, to magnetic separators, water jigs, etc. In unloading vessels and handling into and out of storage grab bucket machinery is used almost exclusively. This class of machinery has been perfected to a remarkable degree in the



CONVEYING APPARATUS IN A DEPARTMENT STORE

operations on the Great Lakes, and in some cases a single bucket picks up fifteen tons of ore at a time. The ore steamers are designed with a view to rapidity of unloading, and a 10,000-ton steamer can now be completely unloaded in five or six hours with four unloaders working together.

Bucket elevators are also used a great deal in handling broken stone from crushers to bins or piles and for handling sand from banks to cars or boats, or in delivering to bins.

In handling grain, conveyors are indispensable, and without them the enormous grain elevators which handle and store such large quantities of grain would be practically impossible.

At shipping points bucket elevators lift the grain to the desired level, and belt or screw conveyors distribute it to the various bins. When it is to be shipped other conveyors receive it from the bins and deliver it to cars or boats. Likewise, at re-shipping points it is handled from cars to bins and from bins to vessels, or the reverse. At one wharf in Philadelphia there are two 36-inch belt conveyors running from the elevator to the end of the wharf, with delivery points to vessels at intervals. The combined capacity of these two conveyors is 28,000 bushels per hour.

In the manufacturing industries conveyors have a very important place in the handling of bulk materials. For instance, in a cement mill, the material ingredients have to be handled over and over again. First they have to go through the crushers and grinding mills, with intermediate storage bins, then through the kilns and coolers and to the clinker storage, then through more mills, and finally to the stock house. In such cases the economical handling from one process to another plays an important part in the cost of the finished product. In similar ways conveyors are used in chemical and fertilizer plants, paint and varnish factories and in plants for manufacturing glass, soap, rubber, brick and pottery.

In foundries conveyors handle the sand to storage bins, or to moulding machines, take the waste or burnt sand from the foundry and deliver pig iron and coke to storage bins, or to the charging floor. In some cases moulding machines are placed alongside a conveyor or moulding table, the moulds being placed on the conveyor as fast as they are made, poured and allowed to cool while moving slowly along. When they come to a certain point they are dumped off on a shaking-out grate, where the sand goes through to be tempered again and conveyed back to the moulding machines, and the flask and casting remain on the grate. This is called continuous moulding, and in at least one foundry conveyors are used to take the empty flasks back to the moulding machines and the castings to the cleaning room and a moving sidewalk facilitates the operation of pouring, by making it possible for the ladle operator to move along at the same speed as the moulds.

At blast furnace plants the molten

metal is poured into moving pig moulds and the conveyor dips down into a tank of water, so that the pigs are quickly cooled while in transit and then discharged over the end directly into a railroad car without having been touched by human hands.

In rolling mills the plates, rails, bars, etc., are handled back and forth from the rolls by live-roll conveyors, which are simply a series of revolving rolls. Ingots, bundles of wire, crop ends and various pieces are also conveyed from one place to another, and even the scale that peels off the metal at the rolls is taken care of with conveyors.

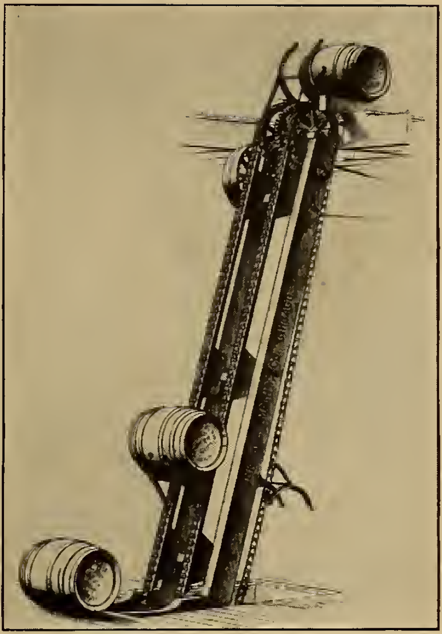
In hardware factories and various metal working plants metal parts are conveyed from one machine to another, or from one part of the plant to another, sometimes being handled through a japanning oven or other process.

At sugar plantations and mills conveyors are extensively used for handling the cane, the bagasse, which is the crushed cane after the juice has been squeezed out, and for handling the raw sugar. Sugar refineries also employ conveyors for various purposes.

In the numerous breakfast food plants the grain is carried through many different operations with conveyors, and some of these plants have very complete and automatic systems. Breweries and malting houses also use grain handling conveyors quite extensively.

In saw-mills an endless chain, with pushers at intervals, is used to take the logs out of the water and up to the saws, and from one place to another. Boards, slabs, bark and sawdust are also handled with conveyors.

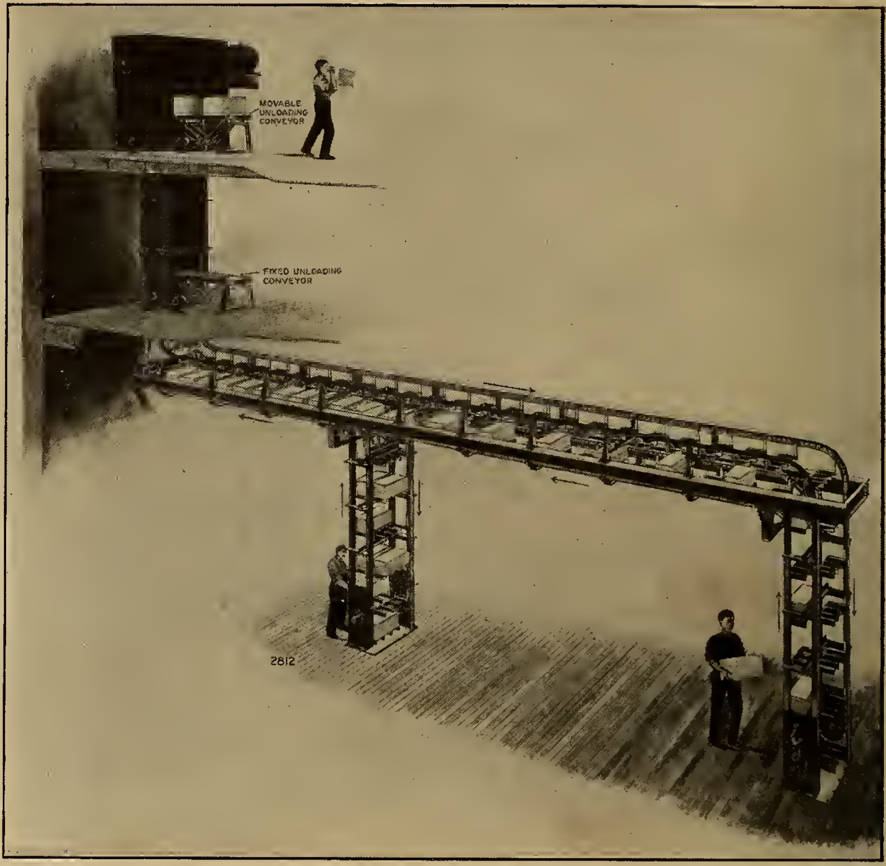
At pulp and paper mills the logs are handled in the same way and after being sawed into blocks they are handled to the barkers and chippers, or to storage, with block conveyors. The chips also have to be conveyed to the digesters or to storage and, in some cases, the pulp is also handled with conveyers.



A BARREL CONVEYOR. LINK-BELT COMPANY, PHILADELPHIA

The handling of barrels, boxes and various packages at shipping and receiving points, warehouses, stores and manufacturing plants, forms a separate branch of conveying machinery, and many special machines have to be designed to meet the various problems. When carrying horizontally or on a slight incline belt conveyors are frequently used for the lighter packages. For heavier work apron conveyors, made up of a continuous line of steel or wooden slats bolted to two endless chains, are used, or the box or barrel is pushed along by some style of pusher attached to one or more chains.

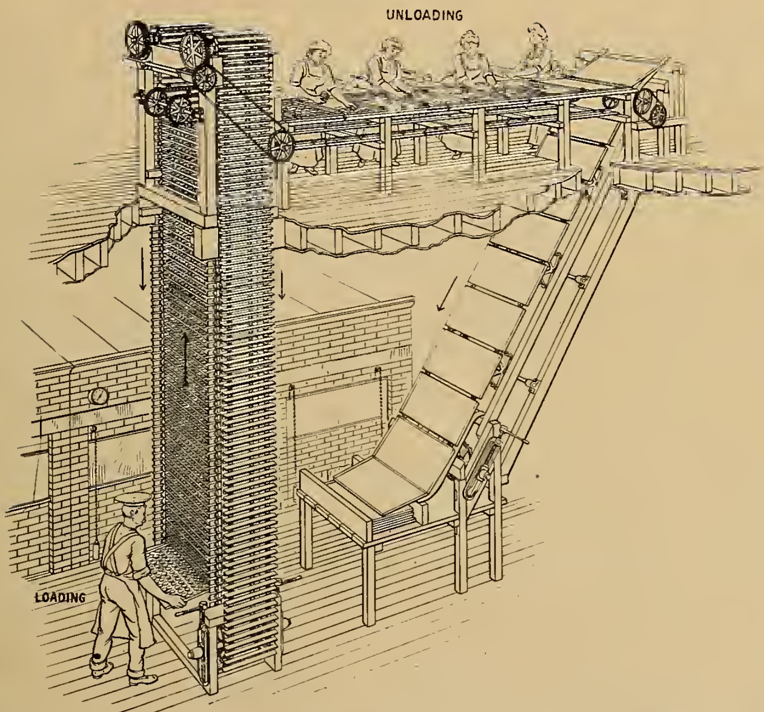
Some of the heavier slat conveyors or moving platforms are called ramps and are used for carrying trucks and miscellaneous freight and baggage to and from cars and vessels, or from one place to another. Where used for loading and unloading vessels the wharf end of the ramp is pivoted so that the outer end



HOW NEWSPAPERS ARE CONVEYED IN A MODERN PUBLISHING ESTABLISHMENT. LINK-BELT CO., PHILADELPHIA

can move up and down to follow the rise and fall of the tide. The stevedore usually rides along with the truck, and where there is considerable tide the ramp is especially valuable, as the slow and strenuous work of pushing the trucks up the incline is avoided. Moving sidewalks and moving stairways also belong to this class of conveyors.

In elevating or lowering barrels, boxes and the like, they are carried on some style of arm or suspended tray, these being spaced at frequent intervals on one or more endless chains. The simplest form of these machines is one with fixed arms, which carries the barrels or boxes up or down and lets them roll or slide off as they pass around the wheels at one end. These machines deliver at only one end or the other. Where it is desired to deliver at a number of points, say several floors of a building, an arm with an automatic tripping device is used. These carry their load up to the desired floor, where a trip has been set, which engages with the arms in such a way that they tip the load off. When used for lowering, the box or barrel usually extends beyond the arm on each side, so that it can be picked off by means of skids or slides placed at any floor. These machines move very slowly, but if the arms are placed quite close together the carrying capacity is very high. For instance, a barrel elevator moving at a speed of 80 feet per minute with arms every 8 feet, would carry 10 barrels per minute, or 600 per hour.



A TRAY CONVEYOR IN A BISCUIT BAKERY. LINK-BELT COMPANY, PHILADELPHIA

THE RECEIVING END OF A BISCUIT CONVEYOR. LINK-BELT COMPANY, PHILADELPHIA

Very little power is required, and no operator is necessary, the attendants simply loading the barrels on the machine and taking them away as they are discharged.

The suspended-tray type of machine consists of two endless chains with pins at intervals on which the trays are hung in such a way that the bottoms always remain horizontal. In some cases the packages are placed on the trays by hand, as they move slowly past the loading points, and taken off by hand as they move by the receiving points. Or, with what is called fingered trays, the packages can be automatically picked up and discharged. These trays have bottoms made up of fingers or slats attached to a cross-rod and spaced far enough apart to allow them to pass between other fingers set at the loading and delivery points. The package is placed on the stationary fingers at the loading point, and the tray picks it up as it passes. It is then carried up and over the head, and as the tray descends, it deposits the package on stationary fingers extending in between the fingers of the tray. These receiving fingers may be set on an incline, so that the package will slide off on a table or on the floor.

In handling newspapers and magazines the suspended-tray type of machine is frequently used. In this case the bottoms are made of cast-iron, with the cross bar at the back, and the fingers all pointing in one direction. The trays pick up the stacks of paper from the loading fingers and carry them up and over the head and deposit them on the unloading fingers on the descending side. These unloading fingers are equipped with moving belts or chains, which carry the papers off out of the way of the next descending tray and the attendants take them away before they get to the end of the belts. In one pressroom the attendants were used to placing the papers on the carrier of an elevator similar to a dumb waiter. This machine moved rapidly back and forth, and when the new slow-moving machine was installed the men said that it made them nervous, as it did not seem capable of keeping up with the rush of papers. They soon learned, however, that the slow-moving machine was more than the equal of the old one, since the trays came along at such frequent intervals, and there was no waiting for the carrier to come back after one load was sent up. Similar machines are used for sending the stereotype plates from the plate-room to the press-room, and for returning the used plates to the plate-room for re-melting.

THE RAILWAYS OF BRAZIL

By Lionel Wiener

VI. THE LEOPOLDINA AND MINAS SYSTEMS—THE LEOPOLDINA RAILWAY.

THE present Leopoldina Railway company is an English one bearing the same name as a Brazilian one, that of the daughter of the Emperor Dom Pedro. It was incorporated in 1898.

The feature of the system is that it covers a definite region: the eastern portion of the States of Rio and Minas, and the south of Espirito Santo; or, in other words, the stretch of country east of the Central Railway and south of Bahia. All the lines originally owned by other companies in this zone have been absorbed and merged into the system.

It thus comprises a number of old undertakings and a large mileage, built by the Leopoldina Company, to connect or develop these lines.

Neither of the two lines leading down to Rio was built originally by the Leopoldina Company.

One of them starts from Rio itself, and one from Nictheroy, opposite. These towns are now connected by a number of steamboats. Many of them belong to the Cantareira Tramway company, and a concession for an electric-tube railway under the bay has been granted.

The older line starts from Maua, at the end of the bay, and scales the Serra, past Petropolis to Entre Rios. A long northern extension reaches Saude, 281 miles away. The Leopoldina company now owns the whole line, besides the bay steamers from Maua to Rio, and has recently purchased the "Norte," or Northern Railway, from stralla to Rio, so as to gain independent access into the capital.

The Nictheroy line was originally the Cantagallo Railway Company, running to Macuco. It is now the first section of two important routes: a northerly one, up the Serra to Novo Friburgo and Porto Novo, the Central Railway's terminal on the Parnahyba River, and on to Santa Luzia, 270 miles; the other, along the coast to Macahé, a seaport, Campos, on the Parnahyba's estuary—the obsolete Macahé and Campos Railway—Muniz Freyr, near the Itapemirim River, and Victoria, capital of Espirito Santo, a length of 275 miles.

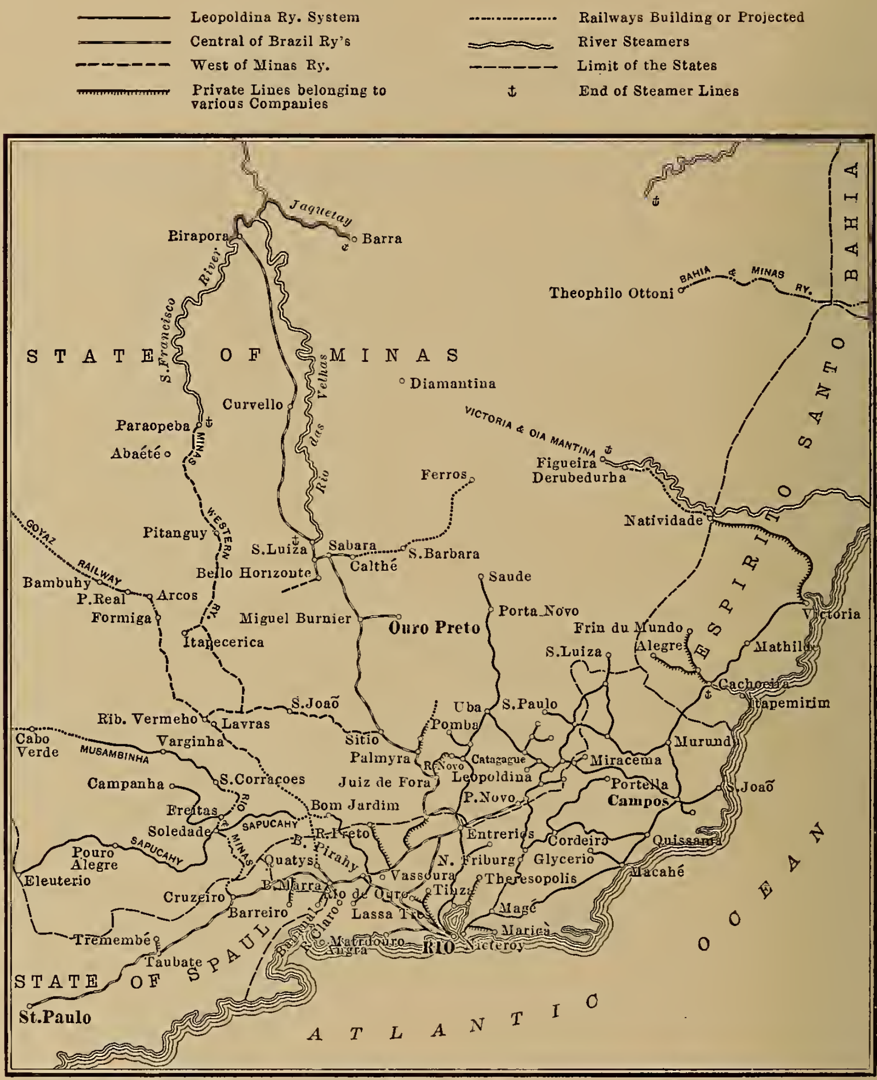
A number of branches connect these main lines with each other, bringing the total mileage up to 1582 miles, the largest mileage in Brazil; 866 are in the State of Rio, 528 in Minas, and the rest in Espirito Santo.

The system is now meter-gauge throughout, a number of formerly 3 feet 7 1/3 inches and of broad-gauge lines having been converted.

On the whole, the radius of the curves is small and the gradients heavy, particularly up the Serra The radius of curves is usually limited at 264 feet and the gradients at 1 in 3; but on these sections the radius of the curves is as low as 131 feet and the gradients reach 1 in 12.

Both the Serra lines are old, and both the Principe de Graó Para and the Cantagallo lines were broad gauge from the bay to the foot of the hills. The former was but 10 miles long and had been built by Viscount Maua, in 1852, and was the first railway line opened in Brazil. It was laid to the 5-foot 6-inch gauge and built without any subsidy. Its immediate success incited promoters to continue railway building, and it was a most powerful argument in favour of railway enterprise at a time when it needed such help.

On May 31, 1881, it was purchased



MAP OF THE LEOPOLDINA AND MINAS SYSTEMS

by the Principe de Graó Para Railway Company, who extended it to Entre Rios, some 92 kilometers (51 miles).

There is a Riggenbach rack section up the Serra between the stations of Raiz and Alto do Serra, 6600 yards apart and 2676 feet above each other. The maximum gradient is 1 in 6.3 and the radius of the curves 430 feet. The original locomotive was ordered from the Baldwin Locomotive Works, and was the first rack locomotive built by them. The cylinders were 12 by 20 inches; the pitch-line of the cog wheel was 41.35 inches, and the weight 15 tons. The next locomotive had two cog wheels and eight supporting wheels; its weight in working order was 79,000 pounds. Many additional locomotives have been put into service since, each with greater power. The maximum load, exclusive of engine, is 28 tons for

passenger and 35 tons for freight trains. The rack weighs 100 pounds per yard.

The journey to Petropolis is accomplished in observation cars, pushed up the Serra in 2½ hours; or else it can be accomplished by boat across the bay, in the Leopoldina steamers plying between Rio and Maua, and from there on by rail.

The substitution of 65-pound rails for the 40-pound ones has caused the journey to and from Petropolis to be accelerated. Monthly season tickets are issued at £10 5s., with a descending scale reaching £15 8s. for the third three-monthly season-ticket. Return excursion-tickets are issued at 9 shillings each.

A new electric line has been conceded, which would compete for the Petropolis traffic. It would bring Petropolis within 36 miles of Rio, and, should it be constructed, would materially cripple the Leopoldina's traffic. The Petropolis passenger traffic, as it is, has been falling off, owing to the improvements of Rio and to the numberless steps successfully taken to turn the capital into a healthful place. Yellow fever is all but extinct, and the general exodus at sunset, of past years, is no longer a necessity. Luckily, passenger-returns on the rest of the system have more than compensated for the decrease on the Petropolis line.

The cost of working the lines leading away from the capital is bound to be high, because the mountain-range keeps so close to the shore, and must be scaled at the very outset. The slopes are exceptionally steep and no gap or valley can be followed to the top.

The other Serra line, from Nictheroy, was built by the Cantagallo Railway Company to Macuco, in 1856, with a recent branch from Cordeiro to Portella.

The Serra portion is reached after a 50-mile run to Bocca do Monte, 717 feet above sea level. Theodoso, the next station, is 2838 feet higher and only 7½ miles beyond.

The line to the foot of the hills originally was broad-gauge, 5 feet 3 inches. Up the Serra it was laid to the 3-foot 7 1/3-inch gauge, with a center rail, for Fell locomotives. These were provided with horizontal wheels that could exert 40 tons pressure against each side of the rail. There were two pairs of horizontal wheels, coupled; their two cylinders were above each other in the center of the engine. Its weight was 25 tons, empty, and 30 tons in working order.

The gradient is 8 3/10 per cent., in combination with curves of 130 feet radius. No fewer than 91 curves and reverse curves occur within a distance of about two miles.

But, as on most such lines, it was soon deemed advisable to do away with the complication of the Fell locomotive, and an inquiry for ordinary locomotives, able to haul 40 gross tons up the incline, and to run at 15 miles an hour on the other parts, was sent by the Brazilian government to the Baldwin Locomotive Works in 1882. The first locomotives shipped to Brazil were built to the following principal specifications: Cylinders, 18 by 20 inches; six driving-wheels, coupled, 39 inches diameter; wheel-base, 9 feet 6 inches; boilers, 54 inches diameter, with 198 flues, 2 inches diameter and 10 feet 9 inches long. These locomotives were satisfactory and ordinary adhesion locomotives have operated the line ever since. The center-rail has been retained in case of breakage. The New Zealand Government Railways are the only company to have retained a Fell-worked incline.

The Cantagallo line is probably the steepest where ordinary locomotives are used without artificial adhesion of any kind. The newer locomotives haul 45 tons.

This line originally ran from Nictheroy to Mocuco, a distance of 111 miles. It was the earliest lease given to the Leopoldina Company, who purchased it from the Province of Rio, the former owner, in 1872.

The Carangola Railway Company is another of the original railways that the Leopoldina early superseded. It owned a small meter-gauge system on the northern bank of the Parahyba River, to wit:

Main line, Campos Murundu Porciuncula...	103 miles.
Itapemirim branch........................	13 "
Patrocinio branch........................	24 "

There was a 7 per cent. guarantee on a capital of £204,750.

This system was transferred to the Leopoldina Company on September 6, 1890, at the same time as the Baraña de Araruama Railway, which was still building. This line of 2-foot 2-inch gauge, had a 6 per cent. guarantee on a fixed sum of £1647 per mile built. It should have joined the Cantagallo Railway with the Macahé and Campos system, from Macuco, the terminal of the former, to Triumpho. The line has been started from Triumpho, but even yet has not effected the junction. It has been built from Triumpho to Manuel de Moraes, about 60 miles, with a short branch from Trajano de Moraes to Santa Maria Magdalena.

We mentioned the Macahé and Campos system; it was made up as follows:

A main line, granted by the province of Rio in 1870, and whose 60 miles from Macahé to Campos were opened to traffic on June 13, 1875.

A line from San Fidelis to San Antonio de Padua, 59 miles long, which the company purchased, but which was separated from Campos by the Campos and San Fidelis Railway Company.

Finally, a steamship service from Macahé to Rio, which the Leopoldina Company has discontinued.

The main line was laid to a gauge of 0.95 meter, and the Padua section to 1 meter.

The capital expenditure was high, owing to much embankment work across the lowlands; the cost, rolling stock included, was £5,204 per mile.

These are not all the companies the Leopoldina Railway has absorbed. The line from Rio to Victoria reached only Muniz Freyr, a few miles from Cachoeira, on the Itapemirim River, down which a steamer-line runs to sea.

From the port of Victoria the State of Espirito Santo had built a railway to Mathilde.

This line was called the South of Espirito Railway, which the Leopoldina wished to connect with its system. The government granted the missing link on condition that the Leopoldina purchase the South of Espirito Santo Railway.

For some 19 miles out of Muniz Freyr, the line is one of the heaviest in Brazil: this section was estimated at £29,000; and, whether it will be a useful addition once it is built, is an open question.

The lines north of the Parahyba River ceased opposite Campos. But as soon as the Leopoldina Company took up the system, powers were applied for to build a bridge across the river and granted, in 1898. The connection is but a mile long and has a 6 per cent. guarantee of interest on £375,000.

The bridge is a six-span one, each span being 181½ feet long, and is built entirely of steel resting upon columns of concrete, 10 feet in diameter at the basis, tapering to 8 at the top; 400 tons of steel have been used for the columns, and 1,080 tons for the superstructure.

The approaches on either bank are upheld by walls of reinforced concrete, 843 feet long on the southern and 33 feet long on the northern bank. The working expenses of this part, considered separately, are 188 per cent of the earnings—1907—but, of course, its usefulness should not be gauged this way.

The Leopoldina Railway Company has cost about £5,700,000 or £39,100 per mile—1907—but this is not the actual building-cost, as a number of lines, belonging to small companies that were obliged to sell, owing to pecuniary difficulties, have be-

come the Leopoldina's property at much less than the cost price.

Owing to these companies having been granted leases under a variety of laws, the Leopoldina Company owns and works lines of every possible origin.

Three of them, the Barao de Araruama—from Compos to S. Joao, 32 miles—the Central de Macahé Company—from Macahé Harbour to Glycerio, straight inland, 27 miles—and the Sao Eduardo to the Itapemirim, 58 miles—were granted a 6 per cent. paper-guarantee by the "Union" on a basis of £3017 per mile. This guarantee, granted in 1888, has been paid over to the Leopoldina Company since 1898, when it became the lessee. Such a guarantee was necessary, the ratio of expenses to gross earnings being far above 100 per cent. for all three lines: 192, 200 and 132, respectively. But the worst from this point of view is the Sumidouro Line, worked at 305 per cent. of the earnings. Small wonder that the carriage of a ton of goods costs 2s. 2½d. per mile.

There are 558 other miles of government lines which have no guarantee from the government, though some have been subsidised by the States. The remainder were granted by the States, some with, some without guarantee.

The Leopoldina Company, while bringing this heterogeneous mass of lines under one management, endeavoured to bring some sort of unification, and started building extensions and connections.

The Grao Para line was continued to Saude; the Cantagallo line, that started from Nictheroy, was extended to Port Novo, with a branch to Portella from .Porto Novo to Santa Luzia, on the one hand, and to Ligacao, on the Saude line, on the other.

There used to be a break at Entre Rios, the continuation starting from Serraria, the next station on the northern line of the Central Railway, 9 miles beyond. A loop has been opened recently, bridging this gap.

In both Entre Rios and Porto Novo the Leopoldina Railway competes with the Central Railway for the Rio traffic. The comparative timing and distances are as follows:

	Central Railway. Miles.	Central Railway. Hours.	Leopoldina Railway. Miles.	Leopoldina Railway. Hours
Rio Entre rios	124	4	80	5
Rio, Porto Novo	163	6	...	..
Nictheroy, Porto Novo	...	..	136	10½

The length is in favour of the Leopoldina Railway, but this line is considerably the harder one.

Both these Leopoldina lines have an important town between them: that is Theresopolis, half-way between Petropolis, its rival, and Novo Friburgo. A separate company works a line from Magé there, on the Bay of Rio, east of Maua. It is 21 miles long and has a 5½-mile rack-section of Riggenbach's type.

The receipts on these Serra lines are deeply affected by the reductions on the Central Railway. It is not quite the game, the Leopoldina having to compete with a railway whose object is solely to work not lower than cost price. The tariffs on the Central Railway are just half those of the Paulista Railway Company.

The capital expenditure of the company is no guide to the actual cost, for a number of lines belonged to former companies that were obliged to sell, owing to pecuniary difficulties, and that have become the property of the Leopoldina Company at considerably less than cost price.

The old companies, which compose the present English company, failed in 1896, with a capital equivalent to about £18,000,000. The debenture holders then wrote their capital down, and exchanged their mortgage-bonds for ordinary shares for £5,000,000. The English company further paid off the £1,000,000 floating-debt, inclusive of £700,000 to the Federal government, who were creditors; £2,500,000 pounds were gradually issued besides, to bring the rolling stock and permanent way,

then in a ruinous condition, into decent repair.

Another couple of million sterling have been put into the country to carry out the recent programme of extensions now in hand.

Before examining the lines, a few words upon those built by the Leopoldina Company itself will be useful.

The Saude line was opened in 1877, to Sao Geraldo, 127 miles, at the foot of the Serra and 1,252 feet above sea-level. Coimbra, the next station, and 16 miles beyond, is 1,133 feet above. This Serra-scaling is one of the most picturesque on the system. The line was opened to Saude, in 1885, a distance of 231 miles from Porto Novo.

There are a number of short branches from it, besides: to Pirapetininga, then to the town of Leopoldina, both opened at the same time as the trunk-line; and from Catazagues to Mirahy, on the one side, and Joao Pinheiro, on the other, opened quite recently.

The Santa Luzia line starts from Recreio, and passes along the terminals of the obsolete Cantagallo Railway.

Finally, there are the Campistan Lines east, from Campos, and a growing group:

Campos to Sao Joao do Barra and Atafona,

The Santa Amaro branch,

The Mussureppe branch,

The Colomins branch.

The new extensions will add some 354 miles, bringing the system up to 1,805 miles. Their completion is expected to take about five years. Of this total 727 miles are owned in fee simple, 528 until December 31, 1999, and 550 revert to the State of Rio or to the Federal government at various dates, with an average tenure lasting till 1961.

The most important of the new lines is the one destined to link the State of Minas with the Port of Victoria. The Leopoldina Company, therefore, purchased, in 1908, the Espirito Santo and Caravellas Railway from Muniz Freyr to Castello and Alegre. This was the last independent line in the system and the latest acquisition. But there was another object to be attained; the link runs from Alegre, the terminal, to Manhuassu and Ponté Nova, near Saude, with a connection from Manhuassu to Santa Luzia. The Cara vellas Railway is, therefore, the first section of the new line. Construction work has been started on both sections and is being carried on with the utmost celerity.

This will complete the system—apart from new branches that may be built eventually.

There is no suburban traffic except in Rio, and this has been hampered owing to two causes. The first is the bad situation of the Rio terminal, but this is to be improved and an extension built in connection with the new port and quays.

The second reason is that a part only of this traffic is in the hands of the Leopoldina Railway, the Central Railway coming in for the lion's share, and three independent companies taking a portion of the remainder. These are the Marica Railway, the Therezopolis, and the Rio local lines. As the annexed map shows, the district is made up of Rio and Nictheroy, close to each other on either shore of the channel leading into the bay, a few islands and some neighbouring towns. The latter can be connected only by railway lines, a number of steamers plying between the former.

(1) On the Nictheroy side, the Marica Railway runs to Marica, on the seashore, 39 miles away, and has been extended even to Ponta Negra.

(2) The Theresopolis Railway, from the bottom of the bay, has been mentioned previously.

(3) There are two local Rio lines, each leading to the summit of one of the two hills that dominate Rio.

The Tijuca line is an electric-light railway, a dozen miles long.

The Corcovado line is a rack rail-

way, electrified in 1909. It is 4,178 yards long, with curves of 400 feet radius and gradients up to 30 per cent., the steepest rack railway with a single exception.

Both of these lines have been worked at a loss most of the time, and both have been taken over by new companies recently.

The Leopoldina system is now homogeneous. I append hereunder a table of the lines, with their mileage and origin:

This statement shows that the percentage of expenses to receipts was 66.7 in 1907, and 68.7 in 1908. This decrease was due mostly to the falling off in coffee, which pays a higher freight than any other article of export. As the system carries a large quantity of coffee, the earnings are largely influenced by the coffee crop. But land cannot bear coffee continuously for an indefinite number of years without becoming "tired." It is, therefore, necessary to throw

TABLE OF THE LINES NOW MAKING UP THE LEOPOLDINA RAILWAY SYSTEM.

Obsolete Company.	Name of Line or Branch.	Section of Line	Footnote.	Miles.
Norte	Northb line	Rio to Estrella junction	2	31
Grao Para	Grao Para line	Maua to Sao José de Rio Preto	3	57
Grao Para	Grao Para line	Areal to Entre Rios	3	16
	Parabybuna branch	Entre Rios to Parahybuna	3	9
	Travessao branch	Travessao to Silveiro Lobo	6	12
	Serraria line	Serraria Ligaçao	6	94
	Pomba branch	Guarany to Pomba	6	17
	Rio Novo branch	Furtado de Campos to Rio Novo	6	5
Leopoldina	Centre line	Porto Novo, Catazagues, Saude	2	231
	Pirapetininga branch	Volta Grande, Pirapetininga	6	20
	Leopoldina branch	Vista Alegre to Leopoldina	2	8
	Miraby brancb	Catazagues to Miraby	6	22
	Sereno sub-branch	Sereno to Joao Pinheiro	6	8
	Muriabé line	Recreio to Santa Luiza	6	93
	Muriahé extension	Santa Luzia to Manhuassu	..	Building
	Paraokena link	Paraokena to Cysneiros	6	1
	Poço Fundo link	Junction to Poço Fundo	6	1
	Sao Paulo branch	Patrocinho, Sao Paulo de Muriahé	6	11
Cantagallo	Cantagallo line	Nictheroy to Macuco	3	112
Cantagallo	Cantagallo extension	Cordeiro to Portalla	3	49
Sumidouro	Sumidouro branch	Cons Paulino to Mello Barreto	2	58
	Seaboard line	Porto das Caixas to Macahé	3	92
Macabé and Campos	Seaboard line	Imbetiba, Macahé and Campos	3	60
Sao Fidelis	Miracema line	Campos Sao Fidelis	3	30
Macahé and Campos	Miracema line	Sao Fidelis, Miracema	3	59
Macabé Central	Macahé Central line	Macahe to Glycerio	1	27
	Araruama branch	Conde de Araruama to Triumpho	3	25
	Araruama brancb	Triumpho to Manoel de Moraes	1	32
	Araruama branch	Trajano de Moraes, S. M. Magdaleno	3	17
Campista	Campistan line	Campos to Atafona	3	33
Campista	Campistan line	Martins Lage to Colomins	3	33
	Saturnina brancb	Campos to Santo Amaro	3	24
	Mussureppe brancb	Martins Lage to Mussureppe	3	5
Carangola	Carangola line	Campos, Murundu, Sao Antonio	2	105
Carangola	Poço Fundo branch	Itaperuna to Poço Fundo	2	21
Carangola	Itabapoana brancb	Murundu, S. Eduardo Itabapoana	2	13
	Itapemirim branch	Sao Eduardo, Muniz Freyr	1	58
	Itapemirim extension	Muniz Freyr to Mathilde	2	50
South of Esp. Santo	S. Espirito Santo	Matbilde to Victoria	2	50
Caravellas	Caravellas line	Muniz Freyr to Alegre	2	45
Caravellas	Caravellas branch	Mattosinhos to Castello	2	45
	Caravellas extension	Alegre, Manhuassu, Ponte Nova	..	Building

(1) Lines conceded by tbe government of tbe union, with interest guarantee.
(2) Lines conceded by tbe government of tbe union witbout interest guarantee.
(3) Lines conceded by the State or Province of Rio.
(6) Lines conceded by the State or Province of Minas Geraes.

Such is the Leopoldina Railway system, after ten years' time, because it should be borne in mind that the present company took over the lines in 1898 only. But, in spite of its efforts and good management, the returns have not, so far, been satisfactory, and the dividends have averaged 2.9 per cent only on the cut-down capital. The results of the company's workings are stated in the table on the following page:

open new coffee land and to encourage other produce.

The coffee tonnage carried since 1899 has been as follows:

Year.	Tons.
1899	117,025
1900	78,230
1901	174,081
1902	150,937
1903	161,297
1904	105,602
1905	126,520
1906	145,996
1907	159,688
1908	142,543

OPERATION OF THE LEOPOLDINA RAILWAY

Year.	Miles Open.	Gross Receipts.	Working Expenses.	Net Revenue Guarantee. Excluded.	Net Revenue Guarantee. Included.	Fixed Charges.	Dividend. Per Cent.
		£	£	£	£	£	
1898	1,289	541,491	460,772	80,719	105,047	46,926	..
1899	1,126	526,876	398,638	128,238	142,305	59,982	1½
1900	1,142	558,657	448,978	109,679	187,729	78,222	1½
1901	1,305	840,330	547,983	292,347	343,615	106,283	3½
1902	1,308	856,222	565,345	290,877	350,397	114,366	3½
1903	1,412	831,494	546,564	284,930	338,949	129,294	3½
1904	1,423	800,032	550,853	249,179	323,644	143,073	3
1905	1,423	1,126,167	732,845	393,322	447,468	142,423	4
1906	1,423	1,182,825	780,203	402,622	477,256	144,000	4
1907	1,489	1,254,557	836,443	418,114	446,018	147,456	4½
1908	1.542	1,206,617	829,134	377,483	402,742	174,250	3½

In 1908, besides the 142,000 tons of coffee a large amount of sugar, 37,752 tons, and sugar cane, 25,418 tons, has also been carried.

The other goods consist of maize, 45,779 tons; beans and cereals, 31,659 tons; salt and flour, 15,000 tons each. Wood and stone also contribute largely to the goods traffic: 55,326 tons of timber, 44,624 tons of fire-wood and 19,634 tons of stone and sand were carried in 1908.

The receipts accruing from goods alone were £377,000 in 1899, the first year of the company's working, and £323,378 in 1908, for 585,414 tons of merchandise.

During the same period passenger traffic progressed from £99,200 to £199,889 for 2,968,898 passengers, and luggage and parcels from £34,390 in the first instance, to £58,264 in the latter. This includes dairy and garden produce.

Only 26 per cent. of the travelers travel first-class, but they contribute 52 per cent. of the receipts. These were contributed as follows:

First-class passenger traffic	£103,582
Second-class passenger traffic	96,307
Parcels and baggage traffic	58,264
Goods traffic	923,378
Telegraph receipts	4,179
Sundry receipts	20,906
	£1,206,617

The receipts, per train-mile of goods, were 10s. 10d., and the expenses 7s. 5d. The net receipts were 3s. 5d.

The public train-miles were 2,230,909, run at a cost of £61 per 1000 miles, locomotive and traffic

The fuel consumption is low. Per 1000 ton-miles, it averages 459.3 pounds of fuel, mostly coal, and 1.47 pounds of lubricants

Vehicle lubricants and waste consumption, per 1000 four-axle vehicle miles, was 7.99 pounds.

The rolling-stock comprises 186 locomotives, 231 carriages, and 1,918 wagons.

Seventeen of the locomotives are rack engines used on the Petropolis Serra, and nine others are special locomotives for working the trains up the Novo Friburgo Serra. Of the remainder 69 are passenger engines. Twelve of these are four-wheel coupled-tank locomotives used on the suburban trains; 28 are four-wheel coupled tender locomotives and 29 six-wheel coupled.

The mixed locomotives are six-wheel coupled, and 40 in number.

The 45 goods engines are eight-wheel coupled.

All carriages and wagons, with the exception of 15 of the former and 198 of the latter, run on bogies.

The coaching stock comprises 74 first-class coaches, 48 second, 57 composites, 5 second and van, and 20 vans.

The wagons are:

The Wagons Are:	4-Axle Stock.	2-Axle Stock.
Covered	1,091	51
Open	512	138
Cattle	47	5
Cattle and van	22	...
Cattle, mail and van	16	...
Poultry	7	...
Cattle and poultry	2	...
Tank	4	1
Inflammable	1	...
Breakdown	16	3
Special coupler	2	...
	1,720	198

A number of these are large-capacity steel wagons sent out from England.

The floating stock plies on the Rio Bay and on the Campos River ser-

vice. The Macahé and Rio Line has been discontinued.

The bay service is maintained by 4 passenger steamers—3 paddle and 1 screw, 5 launches, 4 lighters and 5 pontoons. The river service by 1 paddle-boat and 4 lighters, 3 of which were destroyed in the recent Campos floods.

The maritime service earned £11,-692 from passengers, £5,961 from parcels and baggage-carrying and £58,781 from goods. The expenditure was £38,596.

The following table shows the percentages of the several items of receipts and expenditures for the year 1908:

Receipts.	Percentage.
Passengers	15.53
Parcels and luggage	4.33
Goods	71.20
Government commission	0.67
Miscellaneous	1.94
Maritime service	6.33
	100.00

The government commission amounts to £7,843, and is contributed by the Minas government 0.34 per cent. of the total receipts, Rio government 0.24 per c ent. and the Federal government 0.09 per cent.

This revenue is expended in the following proportion:

	Percentage.
Permanent way and works	20.10
Telegraph and electrical service	0.52
Rolling stock superintendence	1.84
Locomotive maintenance	4.91
Vehicle maintenance	4.75
Locomotive running	9.40
Vehicle running	0.44
Maritime service	3.20
Traffic expenses	16.20
Directorate and management	5.76
General charges	1.60
Net revenue	31.28
	100.00

From the passengers' point of view the train service calls for little comment, a proof it is a good one.

There are three trains a day from S. Francisco Xavier, the Rio terminal, to Petropolis. These trains are run through to Merity, covering 10 miles in 24 minutes. Nine suburban trains stop at the 9 intermediate stations, and take three-quarters of an hour. There are besides, 13 trains from Rio to Penha, only 5 miles out of town.

Through trains are run from Maua—where they connect with the Rio steamers—to Sao Geraldo, up north, accomplishing the journey in a day, and from Nictheroy through Campos to Maricema, in 14 hours. These run through to Porto das Caixas Junction in an hour.

On the whole, the Leopoldina Company is fairly prosperous, and, owing to the fitness of the system to the country it runs through, its future seems one of the most secure in Brazil.

MINAS, WEST OF MINAS, SOUTH MINAS AND GOYAZ RAILWAYS.

These railways, as with those of the Amazon watershed, are interesting because of their possibilities.

The West of Minas is a government road, the rest are in the hands of the Sapucahi Railway Company, including the Rio and Minas and the Muzambinho Railways, both leased by the government. Negotiations have long been afoot for uniting the four companies and for the Sapucahi Railway to work the lot, and were it not for the opposing influence of a neighbouring Sao Paulo company—the Mogyana Railway—this unification would have been accomplished long ago. As it is, the Muzambinho, the Rio and Minas, with a number of extensions, have been merged with the Sapucahi Railway, forming, since 1910, the South Minas Railway Company. The center still belongs to the West of Minas Railway, and the northern extensions have become the Goyaz Railway Company. Each of these lines we will examine successively.

I. WEST OF MINAS RAILWAY.

At present there is no direct connection between Rio and the West of Minas Railway, and even should the Central of Brazil Railway's "Auxiliar" Line be handed over to it,

as seems likely, this will be of little use under prevailing conditions.

The West of Minas trunk line starts from Sitio, on the northern line of the Central beyond the Mantiqueira hills, and runs west 158 miles, to Lavras. Thirty miles short of Lavras, a long northerlp extension runs to Paraopeba, where the Paraopea River falls in the Sao Francisco River, and navigation begins. This long 376-mile line has been laid to the 2-foot 6-inch gauge.

Lavras is the middle of another penetration-line running northwest toward Matalao, and southeast to Barra Mansa and Angra.

It falls short, as a matter of fact, of all these places, and both the end-sections have fallen into alien hands.

The Paraopeba Line was started in 1880, from Sitio to Sao Joao del Rey, a very important town, and was then a 62-mile branch. In 1886 the northern extension, to the north of the State of Minas Geraes, was decided on. Aureliano Mourao Junction was reached in 1887, and Fereira in 1890. This is the nearest point to Itapecerica, a town of some importance 28 miles to the west, to which a short branch leads. The railway then continues down the valley of the Para River. Following the river bank for a considerable distance, it passes opposite Pitangui, on the other bank—and connected with it by a branch line—until some distance before it comes to the Paraopeba River. Taking a westerly swerve, the railway then crosses the Sao Francisco River, at Abbadia, on a 564-foot bridge, passes some distance from Abbaété, and follows the Sao Francisco down to the point where the Paraopeba River falls into it, and beyond which navigation is possible.

It took eight years to open the 340 miles from Sao Joao to Bara de Paraopeba, and that with 21 intermediate stations only.

All the narrow-gauge section, including the Lawras branch, was opened simultaneously.

The other portion was started in 1895. It is really a separate undertaking, even as to the gauge it was laid to—one meter—and joined to the narrow-gauge portion by the Lavras connection. The long Sitio and Paraopeba Line, in the east, and the Angra and Formiga long line, in the west, form two long curves, turning their convexity toward each other and belted together in the middle.

The longitudinal line through Lavras was sensibly laid to the meter gauge. Building was carried on not only from Lavras, north and south, but from Barra Mansa, where it crossed the Sao Paulo branch of the Central Railway, both north and south as well. The company, now defunct, completed the line from Lavras as far as Formiga in the north, Arcos beyond, and had started to work to the Upper Sao Francisco River, which it was to cross in Porto Real. The line was to continue its way north to the very depths of the State of Goyaz.

Southward from Lavras, Carrancas, 50 miles away, was reached, leaving a 94-mile gap, till the northern end of the branch from Barra Mansa, which had reached Cedro, a length of 31 miles. It crossed the Central Railway in Barra Mansa, and went on to Rio Claro, 27 miles farther. All this had been built between 1895 and 1898. But this fine zeal has been unrewarded, and Rio Claro has remained the terminal without another clump of sod being turned to extend the line toward Angrá on the coast, only 41 miles away. But the station of Rio Claro is still 1,422 feet above sea level, and though the Serra is easier to go down here than elsewhere this is still a very arduous piece of line.

These two sections from Barra Mansa have been handed over to the Central Railway, as they were too far from the remainder of the West of Minas system; which is a mistake, should the merging of the

West of Minas with the Sapucah Railway ever take place.

The company runs a steamer service from Lavras down the Rio Grande River to Capetinga.

Deducting the portion handed over to the Goyaz and to the Central Railways, the system still comprises:

Two-foot Six-inch Gauge.		
Sitio to Paraopeba	376	miles.
Lavras branch	30	"
tapecerica branch	21	"
Pitanguy branch	3	"
Meter Gauge		
Formiga Lavras and Carrancas	130	"
Carrancas Cedro, building	94	"
Rio Grande steamers	130	"
	804	"

The eastern extension to Bello Horizonte, the capital of the State of Minas, and built to resemble Washington, has been handed over to the Goyaz Railway and has just been opened to traffic.

A western extension to some point on the Mogyana Railway, probably from Formiga to Sacramento, about 144 miles, underestimated at £718,-800, which would form the continuation of the Bello Horizonte cross-line, is likely to be handed over to the same company whose Araxa Uberaba branch would serve the same purpose.

The West of Minas Company got into trouble, then into debt, and finally into the hands of their creditors, so that the line is now government property.

The metre lines are worked at a deficit; though, owing to the receipts of the other parts, the whole system is not worked at a loss; it just covers working expenses, with a little to spare. This result, disastrous for a private company, is a good one for a government road, because the line opens up a large tract of country, and taxation brings profits in an indirect manner.

Strange to note, curves and gradients of the metre line are harder and more frequent than those of the 2-foot 6-inch section:

Metre Section.	
Curves	330 feet radius.
	57 per cent. of the line.
Gradients	1 in 40
	60 per cent. of the line.
Two-foot Six-inch Section.	
Curves	238 feet radius.
	42 per cent. of the line.
Gradients	1 in 45
	42 per cent. of the line.

Consider the cost of working such a line, where there are more curves than alignments and more grades than level stretches.

There are many bridges on the long northern extension.

The Rio das Mortes bridge, 123d miles, is 180 feet long in three equal spans.

The Sao Francisco River, 326th mile, is crossed on a six-span 594-foot bridge.

The Jacaré is crossed twice on two 200-foot bridges.

The metre-gauge section is carried across the Rio Grande on a two-span, 210-foot bridge, one span 210 feet, the other 110, and across the Capivary River, 26th mile, on a 320-foot bridge, in two equal spans. There is an almost endless number of other bridges of all sizes.

The steamer service down the Rio Grande has been maintained. The fleet comprises five stern-wheel steamers, an inspection and eight freight launches.

Three Yarrow steamers are 81 feet long, 20 feet broad and 4 feet deep, carrying 30 passengers, 12 first and 18 second class. The stern-wheel is 14 feet 6 inches diameter; the cylinders of two of them are 13 13/16 inches diameter by 31½ inches stroke; the other has compound engines.

The fourth, built by Forest & Sons, is a little smaller; it is 69 feet long, 13½ feet broad and 41⅜ inches deep. The stern-wheel is 9 feet 2 13/16 inches diameter; the engines has compound engines and a stern are compound. It carries 16 passengers, as does the last steamer built by Lobnitz.

THE MECHANICAL PURIFICATION OF AIR

By C. L. Browne

THE problem of air purification on a commercial scale has been brought to the front by the wider introduction of the plenum system of heating and ventilation. The removal from the air of the floating particles of dust, soot and other impurities constitutes, especially in densely populated or manufacturing towns, the most serious difficulty in the science of ventilation. The importance of this problem will be fully appreciated when it is borne in mind that with plenum ventilation the fans installed completely change, several times within each hour, the whole of the air in the building which they are ventilating. The volumes of air handled are in many cases enormous. In a public building recently completed in Scotland the heating and ventilating plant has a total capacity of over 212,000 cubic feet of air per minute.

It is thus evident that where large volumes of fresh air are hourly driven into buildings an infinitesimal degree of impurity in the air will, in a very short time cause a dirty and insanitary deposit.

The necessity, however, for the efficient ventilation of public halls, buildings and factories was early recognized, and the fan system of introducing fresh, warmed air into both new and existing buildings was adopted in America and later into England, even though a certain degree of uncleanliness was involved.

The cruder and less efficient methods of air filtration have been superseded by more carefully thought-out and better designed apparatus.

The existing forms of air filter may be roughly divided into five classes: (1) the dry stationary; (2) the wet stationary and the (3) wet revolving filters; (4) the spray nozzle and the (5) revolving spray wheel types.

Perhaps the earliest type of filter used was the dry stationary, which consisted essentially of cheese cloth screens, placed at right angles to the path of the entering air.

Filters of this class, whether employing cotton, jute or cocoanut fibre as filtering mediums, were found to have only a crude cleansing effect upon the air, and after a short period of working, became dirty and insanitary, and thus becoming in themselves a source of impurity, soon defeated their own object.

In addition to the above disadvantage, all filters of this class offer a high resistance to the passage of air. The extent to which a small resistance cuts down the capacity of a centrifugal fan is well known, and the increased power required to drive the fans under these conditions militates seriously against the commercial success of the plant.

These filters have the further disadvantage that they do not affect in any way the humidity of the air handled, and it is now recognized that absolute control of the amount of moisture in the air is an essential qualification in a successful heating and ventilating apparatus.

Dry air produces a more rapid evaporation of moisture from the surface of the human body, and this causes a lower sensible temperature. As a matter of fact the sensible temperature of the body corresponds

more nearly to that of the wet bulb of a hygrometer, than to the temperature of the dry bulb. Air at 68° Fahr., containing 50 per cent. humidity, feels more comfortable than air at 75° Fah., having a humidity of only 20 per cent.

With an outside winter temperature of 30° Fah., and 80 per cent. saturation, the air will contain 1.5 grains of moisture per cubic foot. If, without the addition of moisture, its temperature be raised to, say, 70° Fah., its saturation will be only 19.5 per cent., since air at this temperature is capable of absorbing 8 grains of moisture per cubic foot. Under the latter conditions the atmosphere will greedily absorb moisture from the human body.

Apart from its effect on health, the control of the humidity of the air has its industrial value and perhaps its most important applications lie in the textile industry.

Although the westerly winds that blow in from across the wide expanse of the Atlantic are, as a rule, laden with moisture and thus produce atmospheric conditions such as are favorable to the great Lancashire cotton industry, the east winds that often prevail coming to England across the continent of Europe are comparatively dry, since their short passage over the North Sea does not permit of much moisture being taken up. Thus it is frequently necessary to resort to artificial means for producing the required degree of humidification. The plenum system which gives the right volume of air at the required temperature and humidity, is universally admitted to bring about increased production, stronger, more elastic and more evenly twisted yarn and a better and brighter cloth.

Absolute control of humidity is essential also in cooling and low temperature drying, as will be later explained .

Thus we find the application of water to the stationary filter with the double object of increasing the humidity of the air, and at the same time of cleansing the filter from the impurities that in the ordinary course become lodged therein.

The method usually adopted is to erect vertical screens of fibrous material and to extend horizontally above their upper edges a copper pipe along the bottom of which a series of small, closely-pitched holes have been drilled. The pipe is then supplied with water whence it issues in a number of fine jets, which are directed upon the filtering medium. Experience has proved that neither has this method a fully-controlled effect upon the humidity of the air dealt with, nor have the jets of water the desired cleansing effect upon the filter.

Unfortunately ventilating installations in many large towns have to deal with a smoky atmosphere in which the chief solid impurity is soot. Minute particles of the latter become lodged in the interstices of the fibrous material, and require for their removal a far more drastic treatment than that obtained by the action of water trickling down the screen by the action gravity.

Indeed, in order to lessen the high resistance of such filters to the passage of air, the filtering cloth is, where installed, woven with a comparatively wide mesh, and a very considerable percentage of solid matter passes right through the screen without becoming entrapped by the cloth. There is a practical difficulty in getting sooty particles to adhere to a wetted surface for a sufficient length of time to enable them to be flushed away. Any observant dweller in our industrial centers will have noticed small particles of soot dancing freely along upon the surface of water under the influence of small gusts of wind. It was the recognition of these difficulties that brought about the introduction of the revolving screen.

This type of filter, which has been made in units large enough to deal 50,000 cubic feet of air per minute,

consists essentially of a hollow cylindrical framework, constructed of galvanized steel, the periphery being covered with the filtering cloth. The cylinder is mounted upon a shaft which revolves in gun-metal bearings, the bottom of the drum being immersed in a tank of water. The filter is driven by rope or belt, or by direct coupled motor.

Air, being drawn through the filter by the ventilating fans, enters the latter at the ends and passes out through the wetted material which covers the periphery. The humidity of the air is controlled by regulating the peripheral speed of the filter with reference to the radial velocity of the air, the greater the peripheral speed of the filter with reference to the radial velocity of the air, the more highly saturated the cocoanut fibre is maintained by passing more frequently through the water in the tank, and the humidity of the air is increased in consequence.

This filter, however, is subject in a less degree to the disadvantages of the previously mentioned types, and it has further been found in practice that a portion of the impurities deposited on the surface of the water is picked up again by the filtering mediums as it leaves the tank.

We may now lay down the five main points in an air filter essential to its scientific and commercial success:

(1) The air must be thoroughly cleansed. (2) Its humidity must be under complete control; (3) the filter must be self-cleansing; (4) offer small resistance to the passage of air and (5) require the minimum of running attention.

The fourth type of filter referred to at the commencement of this article is that which has as its characteristic feature the use of the spray nozzle. In this apparatus all fibrous material is dispensed with, the designers being firmly of the opinion that in all woven material, if the mesh is fine enough to be effective, not only is the resistance offered to the passage of the air considerable, but that it is practically impossible to properly cleanse the material from the solid impurities that become enmeshed therein. The air to be cleansed passes through a chamber in which are fixed a number of specially-designed nozzles. The water is forced through these nozzles at a minimum pressure of about 20 pounds per square inch, the path through the nozzle is spiral in direction and the water acquiring a circular motion accumulates sufficient centrifugal force to cause it to burst into a fine spray as it leaves the outlet. The water is thus so minutely divided that its intimate intermixture with the air is assured. Although the nozzles have an orifice of only about 3/32 inch in diameter, each can vent between 3 pounds and 4 pounds of water per minute when supplied at the pressure stated. They are placed in the spray chamber at the rate of two nozzles for every square foot of cross sectional area, and as the usual air velocity through the washer is about 500 feet per minute, the nozzles deliver about 1½ gallons of water per 1000 cubic feet of air per minute. Thus in a plant dealing with 50,000 cubic feet of air per minute 200 nozzles would be required.

Fig. 1 is a diagrammatic representation of the fan and filter combined. The water pressure required by the nozzles is generaly set up by a small centrifugal pump which draws its supply from a circulating tank in which the level is maintained by a ball float and valve which regulates the influx of water in accordance with the amount absorbed by the air.

The effect of the almost-impalpable mist produced by these spray nozzles in the path of the air is such that it is practically impossible for any solid impurities to pass through the spray chamber without being thoroughly wetted. The greater part of the water falls to the bottom of the

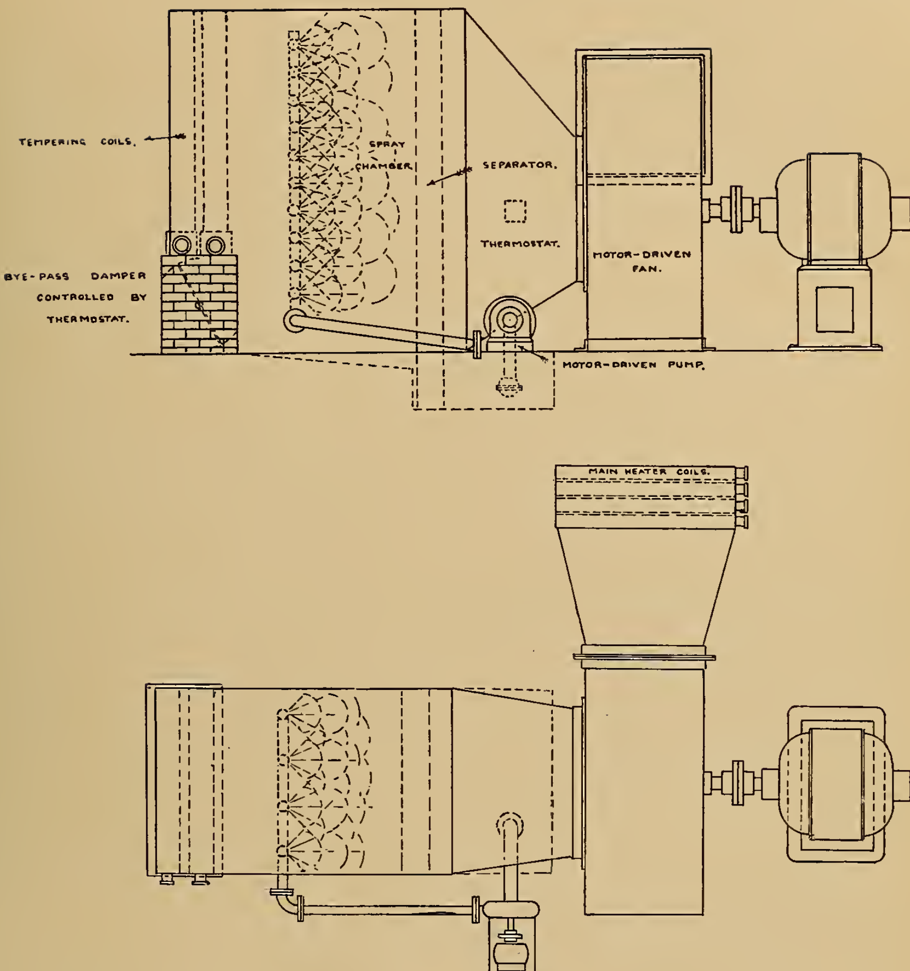


FIG. 1.—DIAGRAMS OF FAN AND AIR FILTER

washer, carrying with it a portion of the arrested impurities.

A certain portion of the spray, however, is carried along by the air current, and to prevent this free moisture from being borne into the building it is arranged for the air to pass through a separator before leaving the washer.

This separator consists of a series of galvanized steel plates about 18 B. W. G., in thickness, pitched about ⅞ inch apart. The sheets are bent as shown in Fig. 2, which gives a sectional plan of the sheets as arranged in the washer. They are generally fixed about 4 corrugations deep as shown in the figure. The spray following the direction of the arrows infringes against these plates, the surfaces being usually covered with a thin film of water as far as A, but the projections at A and B formed by the lap of the plates prevent the egress of free moisture from the filter. It will be noted that the wetted surfaces of the separator form an additional washing area equivalent to about 16 square feet for each square foot of cross sectional area of the filter. The separator plates are, owing to the constant

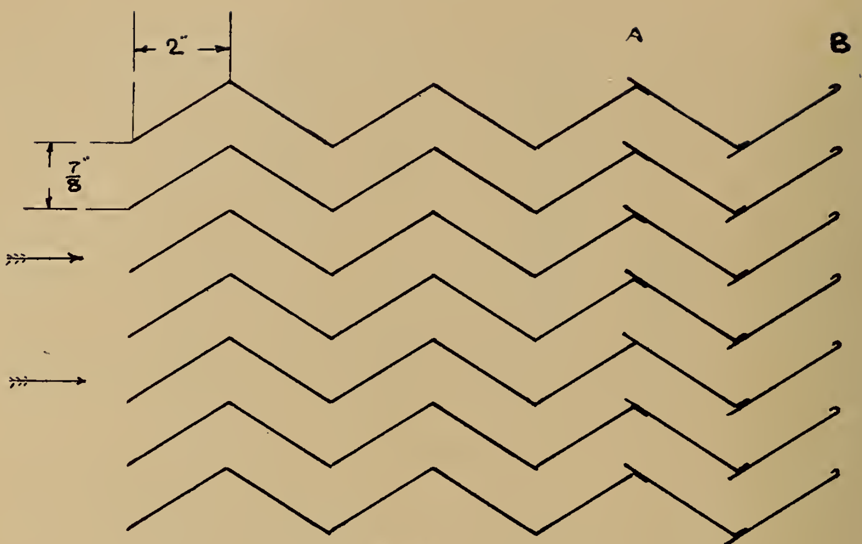


FIG. 2.—HORIZONTAL SECTION THROUGH SEPARATOR PLATES

dashing of fresh water against them, self-cleansing; but provision is made for flushing the plates at any time by the simple operation of turning on a water tap.

In the earlier designs of separator of this type ordinary sheets of commercial corrugated iron were used, but the form shown above is much superior.

This is a most ingenious air washer and humidifier, and has met with a large measure of success in difficult situations. The theory embodied in its design is, of course, that given a sufficient volume of water, broken up to the required degree of fineness, and provided that the velocity of the entering air does not exceed that arranged for, no particle of foreign matter can pass through the spray zone without being wetted. Those particles which do not fall to the bottom of the spray chamber with the water are carried along into the separator, and their inertia being increased by the added moisture, strike against the wetted plates and are washed down into the tank.

There is, however, a danger in breaking up the water too finely. The celebrated "London fog" consists of just such particles of soot impregnated with moisture as described above, but so small that the effect of their inertia towards causing them to strike against the separator plates when passing through it would be almost negligible. However, in tests with carefully arranged washers of this type, when an ample supply of water has been provided, 99° of lamp black, when thrown into the spray zone, has deposited in the washer.

The spray nozzle filter also gives a very efficient control over the humidity of the air handled. This is chiefly effected by varying the temperature of the air in the spray chamber, thus taking advantage of the fact that the capacity of the air for absorbing moisture varies with the temperature of the former. Thus, if air be raised in temperature from 50° Fah. to 70° Fah., its capacity for holding moisture is doubled.

Suppose that it is desired to keep the air in a building at 70° Fah., with 50 per cent humidity, and that the outside temperature is 36° Fah., it would first be necessary to raise its temperature either in the spray chamber by using hot water in the nozzles, or by

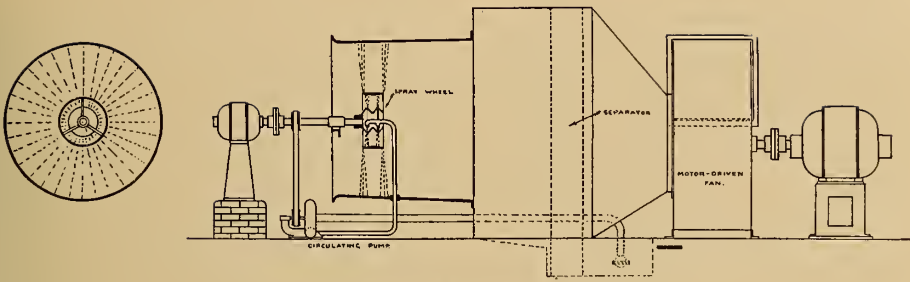


FIG. 3.—REVOLVING SPRAY WHEEL AIR WASHER

passing the air through steam-heated tempering coils before entering the washer. The air could then be completely saturated at 50° Fah. when it would be drawn through the main heater coils to raise its temperature to 70° Fah. Whereas air at 50° Fah. can only hold 4 grains of moisture in suspension, when raised to 70° Fah. it can absorb 8 grains. Consequently air delivered into the building at 70° Fah. would have 50 per cent. humidity.

It might appear at first sight that humidifying the air might result in the condensation of moisture upon the window panes. All danger of this can be obviated, however, by maintaining the temperature in the spray chamber never higher than the mean between the temperature of the room and that of the external air. To take as an example the conditions assumed above, namely: inside and outside temperatures of 70° Fah. and 50° Fah., respectively, if the temperature of the spray chamber is less than 60° Fah. condensation on the windows is an impossibility, since the latter are themselves at a temperature which is a mean between the inside and outside temperatures, and is consequently unable to lower the air to its dew-point.

By control over the humidity of the air its temperature in summer can be lowered considerably, except on such occasions, rare in England, when the atmospheric heat is accompanied by excessively high humidity. It has been proved in practice that an absorption by the air at from .8 to .9 grains of moisture per cubic foot produces a lowering of the temperature of from 7° Fah. to 8° Fah.

In cases where excessively high humidities are met with the air can be thoroughly washed without increasing its moisture by using instead of moisture a solution of calcium chloride 28 degrees Baumé. This solution will neither give out nor absorb moisture.

If the strength of the solution be increased to, say, 40 degrees Baumé, it will actually extract moisture from the air, and in difficult cases, such as low temperature drying, a strong solution of calcium chloride has been used. It should be added that in modern plants the humidity and temperature of the air are automatically controlled by thermostats suitably placed. The last type of filter enumerated at the commencement of this article is that in which the place of the nozzle is taken by a revolving spray wheel. A diagrammatic sectional view of such a washer is shown in Fig. 3.

This washer was designed with a special view to preventing the fine mist in the spray chamber from being carried away through the separator along with the solid impurities that should be eliminated. It is obvious that the cleansing and humidifying effect of the spray becomes small as the latter tends to become stationary with reference to the air, which occurs when the water is carried along in the air current. The increased humidifying effect ob-

tained by opposing the direction of discharge from the nozzles in the previous filter to that in which the air is moving is most marked. The strong current of air, however, soon reverses the direction in which the atoms of spray were originally projected, and owing to their lightness carries them in suspension.

When a fine spray is used for the purposes under consideration, it is necessary in the first place that the water be in motion with reference to the air; secondly, they must at any moment occupy the whole cross-sectional area of the washer in sufficient numbers to effectually cleanse the passing air, and thirdly the water must be broken up to just that degree of fineness requisite to produce the desired humidification. In addition to complying with the above conditions, it is claimed that the spray wheel, throwing off the water in a direction at right angles to the path of the air, gives the former sufficient momentum to prevent its being deflected from its path and carried away.

The tendency of a moving current of air towards entraining the finely-divided drops of water depends upon the pressure exerted upon them.

This pressure in kilo. under conditions of velocity and area obtained in practice is for plane surfaces

$$P = K\ W\ A\ \frac{v^2}{2g}$$

where W = the weight of 1 cubic meter of air in kilos, A = the plane surface of the drop in square metre, v = the relative velocity between air and plane in metres, g = the acceleration due to gravity (9.81) K = a numerical coefficient.

According to Grashof, this coefficient is largely dependent upon the size of the surface and is for surfaces of

K.=	1.86,	2.04,	2.18,	2.34,	2.51,	2.69
sq. m.	1.00,	0.25,	.5 ,	1.00,	2.00,	4.00

Thus K decreases with decreasing surface and consequently the more finely divided the spray, the greater is the entraining effect of the air upon it in proportion to the size of its particles.

Guided by recent results as to the resistance offered by the air to the passage of small spherical projectiles, it can probably be assumed that the value of $K = .55$ when the sectional area of spherical drops is from .1 to .01 square metre millimetre.

The air pressure on the floating drops would then be

$$P = \frac{0.55\ W.\ A.\ v^2}{2g}$$

The globule of liquid has been assumed to be spherical, but this is only the case when forces continue to act evenly upon it. Whereas the unbalanced air pressure soon flattens the side upon which the pressure is exerted, and by increasing its area increases also the value of K.

This circumstance, which is beyond ordinary calculation, must be neglected, although it tends to increase the pressure on the drop.

When a drop of water is loosened from a fixed point and falls, neglecting friction, its velocity y after a time t and a height h through which it has fallen are connected by the well-known equations

$$t = \frac{v}{g} = \sqrt{\frac{2h}{g}}$$

When a drop of water falling vertically meets a horizontal current of air, the former is deflected from its vertical path. If the horizontal pressure on the drop, as expressed in equation (2), commences at the moment of its fall and is equal to its weight, the drop falls at an angle of 45° with the vertical, since its vertical and horizontal accelerations are equal. If under the same conditions the air pressure is several times as great as the weight of the drop, the directions of fall may approach the horizontal. Should the drop, however, have fallen vertically through some distance before meeting the side current, its deflection from the

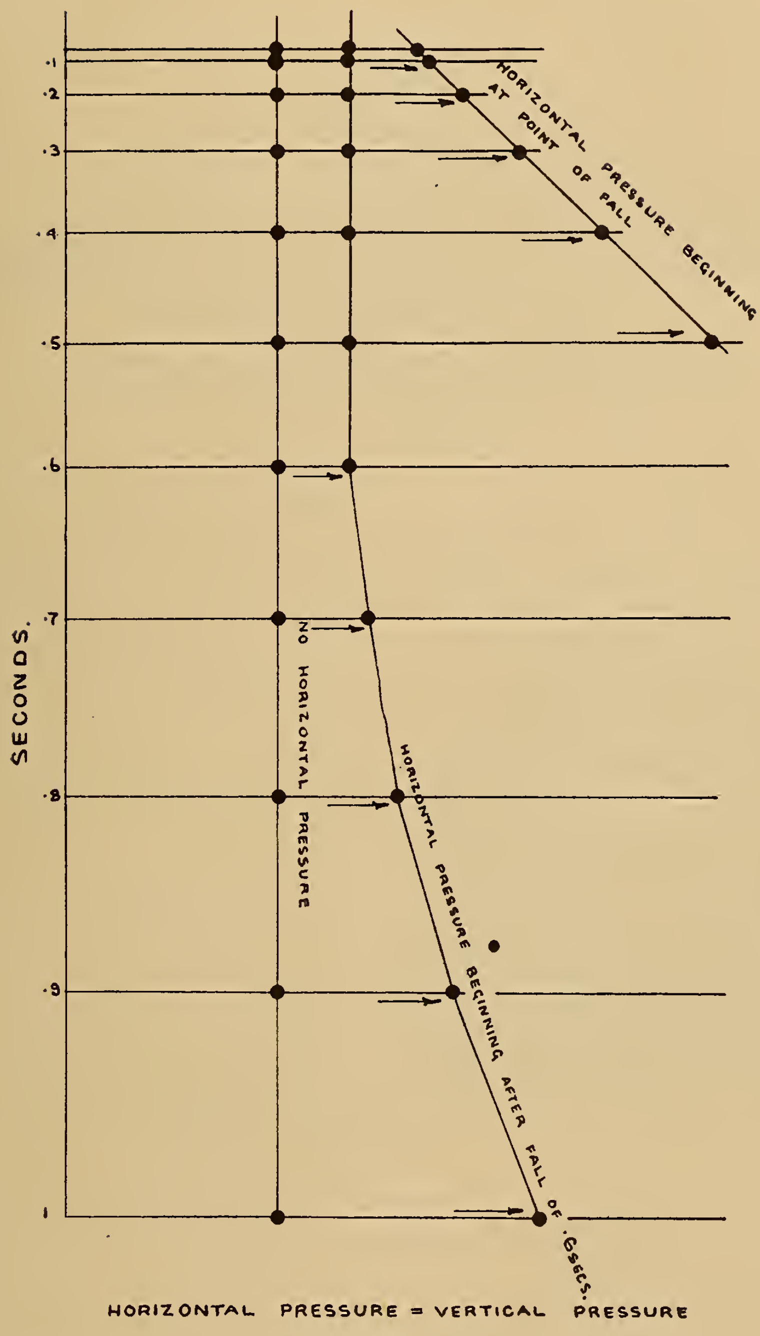


FIG. 4.—DEFLECTION OF FALLING DROPS

vertical is considerably less, since in equal time intervals the vertical velocity is greater than the horizontal.

Thus the danger of the drop being carried away in the air current is very much less. This is made clear by the diagram in Fig. 4. It is on the above facts that the design of the spray wheel air washer is based.

Referring again to Fig. 3, the spray wheel is mounted on a turned shaft supported in two bearings within a tubular casing. The shaft is direct-coupled to an electric motor, the speed of which can be varied by field regulation. The water supply to the wheel is controlled by a small belt-driven centrifugal pump which raises the water from the circulating tank. The water is thrown at a high velocity from the periphery of the spray wheel which travels at a lineal speed of not less than 6000 feet per minute, and consequently its deflection by the air current is practically *nil*. The "carry over" of free moisture into the separator due to the water splashing against the sides of the casing is very small in amount.

Any floating dust or other impurity in the air, on entering the spray zone is dashed and hammered against the sides of the casing, whence it is washed down by gravity into the tank below.

The finest of the spray, and consequently the degree of humidity given to the air is regulated by varying the speed of the wheel, and the quantity of water in circulation is controlled by a handcock.

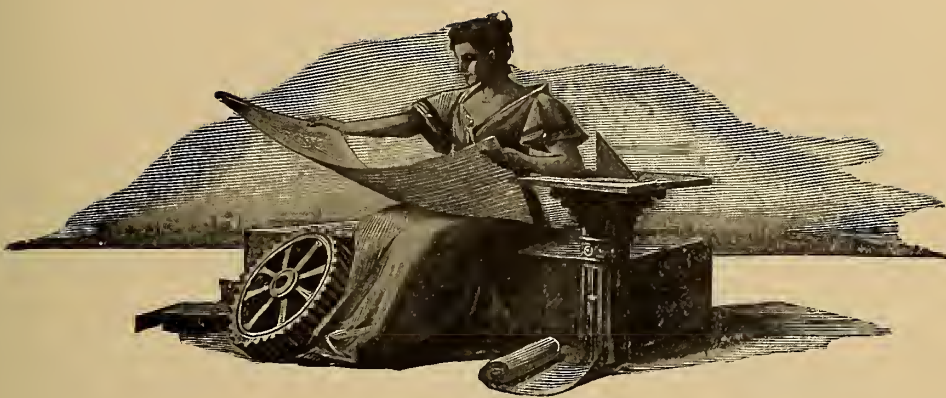
The resistance offered to the air in passing through the washer is negligible, and its self-cleansing properties are obvious, indeed this air purifier conforms in a remarkable degree to the conditions laid down earlier in this article.

One of these washers was supplied recently in connection with the plenum ventilation plant for a large public building in Glasgow, where the problem of cleansing the air was aggravated by the necessity for taking in the air at the roof level. In less than five minutes after starting up the water in the circulating tank was discolored and a film of soot was seen to be floating on its surface.

The introduction of pleum ventilation into England has caused the springing up of a new and important industry, and that one of its most serious problems has been tackled in a thorough and scientific manner, and with a growing measure of success has been sufficiently indicated in this article.

The introduction of pure, warm, humidified air into public buildings by the scientifically-designed apparatus of the present day, enables the city dweller to enjoy one of the delights of a country walk on a summer's evening, after a heavy downpour of rain has refreshed and purified the air.

In conclusion, the writer wishes to express his indebtedness to Mr. Julius Hanna, whose name is identified with original research work in the science of ventilation. It was owing to the courtesy of Mr. Hanna in his capacity as manager for Messrs. Musgrave & Co., of Belfast, that the writer was enabled to make a series of interesting tests of the "Rainbow" purifier manufactured by his firm.



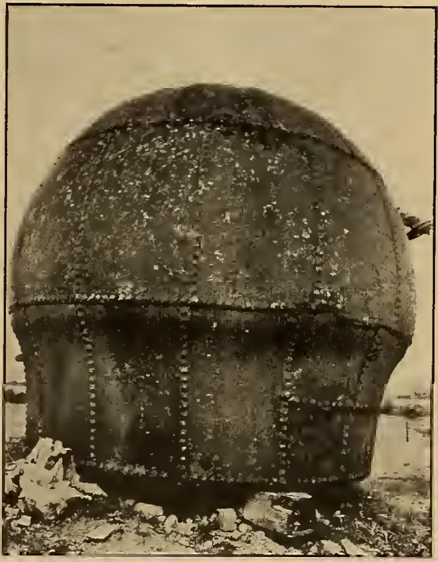
Current Topics

AN interesting bit of engineering history, or rather antiquarianism, appears in the accompanying illustrations, sent to us by Mr. H. Maplethorpe, of Darlston.

Steam boilers naturally are much shorter lived than the steam engines which they serve, and hence actual examples of old-time boilers are much fewer than of old engines. The haystack type, one of the earliest, is now practically extinct, and hence the illustrations and data concerning this boiler are of especial interest.

This boiler is situated at No. 9 Colliery, Pelsall, Staffordshire, where it was photographed and measured by Mr. Maplethorpe, and the accompanying sketch made. It is composed of 49 irregular-shaped plates of various sizes, arranged in four tiers, with a circular plate at the top. The central portion of the underside of the boiler is formed of two semi-circular plates. The seams are single-riveted, and some of the joints match each other, while others are staggered.

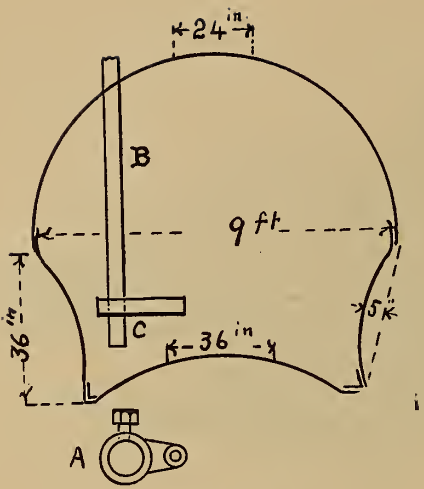
The first tier has 17 plates, the second 16 and the top and bottom tiers have each 13 plates. The height of the first tier is 3 feet, while the second is 3 feet 4 inches. There is a blow-off cock at the bottom of the boiler, while a feed-pipe is placed 2 feet from the bottom.



OLD HAYSTACK BOILER

As shown in the sketch, there is a 2½-inch pipe fitted inside of the boiler, with a projecting arm, indicated at *A, B* and *C.* This was probably some portion of the old-time float-and-chain water-gauge and feed arrangement.

It is unfortunate that such relics



SKETCH OF OLD HAYSTACK BOILER

are allowed to go to the scrap-heap, or rust away, and it seems desirable that this old boiler should be preserved in some technical school or public museum.

PAINT is one of the most important compounds with which the engineer has to deal. Yet it is one that receives very little attention. Mr. Depieires, who wrote a paper on the subject of paints before the Paint and Varnish Society some time ago, called attention to what was desirable in paints and painting. Thus, to begin with, an iron surface to be painted should be of that clean metallic gray colour which may be seen in a properly pickled surface. To our mind, the best surface of iron on which to paint is one that has been first cleaned from grease by a strong alkaline wash and then pickled in weak acid and washed clean of all the acid. Then it should be washed in hot water and painted on the surface that has dried out by the stored heat derived from the hot water. The paint should be put on warm and free from water, and well brushed in to remove air bubbles. This first coat should dry hard and should be lightly rubbed down to open any air vescicles before the next coat is applied. Each succeeding coat should be a trifle more elastic than its predecessor. We fully recognize the cheap folly of air-sprayed paint. Such work is only fit for the application of coloured water washes to suit temporary structures, as exhibition buildings of the flimsy order. The paints must, of course, be thoroughly mixed with the proper ratios of pigments and of oil. Now, all this is exceedingly sound, but it is a most difficult matter to carry out. For example, in bridge and girder work. These structures are prepared in the workshop and are machined, and more or less smeared with various oils or greases, and they never are cleaned, but are built into place, and painted probably in moist weather without having been cleaned or dried in any way. And when a girder is painted, what is done to ensure that water is dried out from the narrow crevices between adjoining surfaces? Just nothing. But in theory such parts should be made hot and painted freely and made to absorb paint so as to shut out all entry of subsequent moisture.

Mr. Depieires prefers sand blast cleaning methods to such methods as scraping and steel brushes. Rust is the great enemy to contend with. Rust has the property of carrying oxygen so that it spreads from a center and will creep insidiously under paint. Ironwork almost invariably fails by corrosion in spots. These spots show up very plainly, and ought to be scraped and sand blasted and at once repainted. The whole surface need not be repainted unless the spotted surface is objected to.

The process might be expensive, but we venture to say that if the parts of bridges are properly cleaned in the shop and dipped hot in oil, this being brushed in and off, such pieces could next be painted once in the shop and finished in place and would show no rust spotting if periodically painted. But most structural painting is only the hiding of rust, for it does not seem to be the practice to remove rust thoroughly before painting.

DR. GISBERT KAPP, M. I. C. E., M. I. E. E.

Professor of Electrical Engineering in the University of Birmingham and President of the Institution of Electrical Engineers

A BIOGRAPHICAL SKETCH

IN the electrical world there is no better known figure than that of Dr. Gisbert Kapp, M. I. C. E., M. I. E. E., and president of the Institution of Electrical Engineers. Dr. Kapp is an Austrian by birth, though of German-Scottish parentage, and is a naturalized Englishman. He was born at Mauer, near Vienna, in 1852, and at an early age he showed a strong bent towards the profession of engineering, and for a number of years pursued his scientific studies in the Zürich Polytechnic School. After completing his education there, he spent twelve months on board ship in hard practical work in the engine room, during which time he gained much valuable experience. At the age of twenty he obtained his first appointment as engineer in a German factory.

He came to England from Vienna when about twenty-two years of age, obtaining almost immediately the post of chief draughtsman to the well-known engineering firm of Messrs. Gwynne & Co., of London, with whom he remained for five years.

In 1879 he became the technical representative of Messrs. Hornsby & Sons, Ltd., agricultural implement makers, of Grantham, and traveled for the firm in many parts of Europe and the East, including Italy, Russia, Egypt, Cyprus and Algiers, studying the varying conditions under which agriculture was pursued in those countries, and adapting the various steam machines to the special needs of each locality. A visit to the Paris Exhibition of 1881 proved to be the turning point of his career, as it was of more than one other engineer. It was the first occasion on which an electrical exhibition of any importance had been available to the student, and it made a deep impression upon him—so deep, indeed, that he resolved then and there to devote himself for the future to the practical study of electricity, of which he foresaw the enormous capabilities. For this reason, in 1881, after two years spent with Messrs. Hornsby, he threw up his appointment and gave himself up entirely to electrical engineering.

In 1882 he returned to London and obtained an appointment with Messrs. Crompton & Co., of Chelmsford. Colonel Crompton made him general manager of the works, and he became closely associated with that gentleman during the early stages of the development of his firm. They collaborated in a system of compound winding for dynamos, and Professor Kapp was already at work on the first of the long series of patents which have made his name known all over the civilized world.

In 1894 he was offered and accepted the post of General Secretary of a newly founded scientific society in Germany, the *Verband Deutscher Elektrotechniker*, or Association of German Electrical Engineers. This position he filled for ten years, at the same time acting as editor of the society's paper, the *Elektrotechnische Zeitschrift*. He also held the appointment of Lecturer on Electrical Engineering in the Charlottenberg Technical University.

When, in 1904, it was decided to

endow a separate chair of electrical engineering in the Birmingham University, it was felt that the one man pre-eminently fitted to fill it was Professor Kapp, whose brilliant abilities had gained for him a European reputation in electrical science. He was, therefore, offered the position, which he decided to accept. He began his active duties in connection with the Chair in October, 1905, and his personality soon made itself felt in the department over which he has control. The equipment of this department in the new university buildings at Bournbrook has been entirely under his direction, and it is no exaggeration to say that no more finely equipped laboratories at present exist in any of the universities or technical schools in England or in other countries.

Professor Kapp has been a voluminous writer upon electrical science, and, in addition to many papers printed in the transactions of the leading scientific societies, both of Great Britain and of the Continent, has published a number of books.

Professor Kapp holds the honorary degree of Doctor of Engineering in two German universities, and is a Master of Science of the Birmingham University. He is an honorary member of the Physical Society of Frankfort, one of the oldest and most important of German scientific bodies, and a member of the English Institution of Civil Engineers. He has served three times on the Council of the Institution of Electrical Engineers, from 1891 to 1893, and in 1905-6, and was vice-president from 1907-1909. Last November a still higher honor was paid to him in his election to the presidentship of the institution. For two years he was the chairman of committee of the Birmingham branch of this institution, and he has also served as president of the Birmingham University Engineering Society.

Professor Kapp, who married in 1884 Miss Theresa Mary Krall, has two sons, the elder of whom has begun practical work in engineering with the well-known firm of Brown-Boveri & Co., in Switzerland, while the younger is still studying in the Birmingham University.

Manufacturing News

Waterproofing Compounds

BOTH in the cold storage vaults of the new Gimble Building, in New York, now nearly completed, and in the cold storage departments of the new Terminal Building of the Pennsylvania Railroad, in order to insure the most perfect damp-resisting surfaces, all cement used on and between the walls, ceiling, columns, etc., was treated with Lapadas compound throughout. The effectiveness of this waterproofing compound, which is readily taken up by the gauging water and equally distributed into every part of the mass, thereby assuring uniform efficiency, is now greatly appreciated, as it is found to possess advantages that have long been sought. Still another purpose for which Lapadas is being much used is as a waterproof lining for the storage tanks used in the manufacture of ice. It has been found that a 1-inch lining applied to the inside of such tanks, after the forms have been pulled, without treatment of the mass at all, will, even though such tanks are subject to variations in temperature from below zero to 80 degrees above, give the most satisfactory results.

St. Louis Aero Show

AT the Coliseum Building, St. Louis, from November 17 to 24, will be held the St. Louis National Aero Show. This show is under the auspices of the Aero Club, and will be a very full exhibition of air vehicles of every practical type and accessories, as well as materials used in their manufacture. Present indications all point to a most interesting and successful exhibition. Full information can be obtained from Mr. G. L. Holton, Manager, Coliseum Building, Chicago.

Concrete Coast Defenses

RECENT tests at Sandy Hook of the resisting power of reinforced concrete as a defense against high-powered projectiles confirm the calculations of the penetrating power of the 12-inch gun. A concrete wall, 20 feet thick, heavily reinforced with steel beams, was pierced by a 12-inch projectile fired at high velocity. The blow delivered was sufficient to penetrate 22 inches of armor plate, and the reinforced concrete withstood the attacks so well that it will probably be used in the construction of the new coast defense fortifications in the Philippines.

WESTINGHOUSE UTILITY MOTOR POLISHING IN THE HOME

Westinghouse General Utility Motor

THE general utility motor now being placed upon the market by the Westinghouse Electric & Manufacturing Company marks the latest advance in the application of electric motors to household convenience. By means of its special attachments the motor can be adapted to a variety of uses about the house. The new motor commends itself heartily to the favour of central station companies, as it provides another wedge for the introduction of electricity into the home. Furthermore, it is essentially a day load. The motor takes from 40 to 120 watts for its operation.

The general utility motor can be readily arranged to operate the following devices: Family sewing machine, buffing, polishing and grinding wheels, ventilating blower, jewelers' lathe, light machinery, small lathes, sign flasher, moving-window display, mechanical toys, etc. The motor is sold complete with one or more attachments. Further attachments can be obtained by the purchaser as desired. A different attachment is not necessary for every one of the uses mentioned above, as some of the attachments make the motor available for several purposes without change. The general utility ventilating outfit is one of the features of the new apparatus. The small blower will supply fresh air to the kitchen, increase the draft of a furnace, remove foul air from sick rooms, and readily adapt itself to any small ventilating work. By fitting the blower openings with suitable pipe, air currents can be directed wherever desired.

The general utility motors are made for operation on 115 and 230-volt direct-current circuits, and on 110

and 220-volt alternating circuits of 60 and 133 cycles. The direct-current motors are shunt-wound, while the alternating current motors are of the induction type, single-phase. The motors run at a speed of 1,700 revolutions per minute. The motor is light and can be easily carried from place to place by means of a handle in the top of the frame. It is artistically finished in black enamel to harmonize with the other house decorations. The applications of the attachments are positive; it is impossible to put them on wrong.

Rubber Mats for Power Houses

A RUBBER rug designed for use in power houses, elevators, depots, hotels, offices and public buildings has just been placed in the market by the Essex Rubber Company of Trenton, N. J. This firm, so well known for its engineering specialties, such as valves, gaskets and moulded or other rubber articles, which they manufacture in hundreds of odd shapes, qualities and consistencies, and which are used in almost every branch of engineering or manufacturing work, has produced a rubber rug of great beauty and utility. It is a heavy rug of new and novel construction, made to take the place of perforated mats and other floor covering which are easily injured. In fact, their new rug is designed for hard and heavy service and is well adapted for it. The Essex rug is reversible, repairable, and can be rolled up tight and stood on end without injury, and contains no cloth or other fabric to rot or break. It has a semi-invisible metallic re-enforcement, thus making it practically indestructible, while its handsome appearance, combined with its great utility, makes it the most economical article of its kind yet produced. Those interested in material of this character would do well to write the Essex Rubber Company for descriptive matter, color plates, etc.

The Romance of Astronomy

THE steady demand for books of popular astronomy seems to have more to do with the romance of the subject than with the desire for scientific knowledge. Even the astronomers give the inexhaustible mystery of the subject—its constant stimulus to the imagination—as the best reason for studying and writing about it. Garrett P. Serviss says in "Round the Year With the Stars," his latest volume, "The writer's only real excuse for appearing again in this particular field is that he has never yet finished a book and seen it go forth without feeling that he had overlooked or cast aside a multitude of things quite as interesting as any he had touched upon. Accordingly, he yields once more to the lure of this illimitable subject, and strives again to find expression for the thoughts it continually awakens and to exhibit the endless procession of marvels which streams before him who knows and loves the stars."—Harper & Brothers, New York.

The annual meeting of the American Street and Interurban Railway Association will be held at Atlantic City, N. J., October 10 to 14 next.

"Handling Coal" is the title of Bulletin No. 42 just issued by the Jeffrey Manufacturing Company of Columbus, Ohio. It is illustrated by photographic views, showing the actual installations where Jeffrey conveyors are used in some prominent places, and describes by text and illustration the various types of screens, roll crushers, pulverizers, hoists, dump cars, larries, electric locomotives and coal cutting and conveying machinery manufactured by them. The same company has also issued a small book which might well be called a Story Without Words, as it describes mainly by illustrations their methods of handling and treating stone, ore, sand, gravel, cement, etc. Copies of this publication will be sent on application.

Industrial Education for the Employed

THE supplementary instruction of men already employed in the industries, by means of evening classes, is a phase of industrial education which is now regarded as both necessary and advantageous in producing efficient workers. A few of the large manufacturing plants conduct their own classes, but more often the instruction is given as an adjunct of a manual training school, a Y. M. C. A., or a technical school.

Franklin Union, recently established in Boston, is unique in that it has been organized and equipped with the sole object of instructing men employed in shops and drafting rooms. Established from a bequest of Benj. Franklin, the school is directly under the charge of an incorporated board, known as The Franklin Foundation, which is also a department of the city of Boston.

The instruction is thoroughly practical, to supplement the daily work of the students, and yet is specialized to fit the particular trades as far as is possible in a city of varied industries. No attempt is made to teach shop work. Saturday afternoon classes were started with success last year in addition to the evening classes. Nominal fees are charged.

Courses are offered in Machine Construction, Electricity, Steam, Architectural Working Drawing, Structures, Industrial Chemistry, Sheet Metal Drafting, Mechanical Drawing, Estimating for Builders, Heating and Ventilating, Gas and Gasolene Engines, Practical Science, Shop Arithmetic, Concrete Construction, Structural Drafting and Expert Watch Making. The laboratory equipment of motors, generators, steam and gasolene engines and accessories is most complete, and consists of the latest commercial types.

That the school has met a need is shown by the registration during the past year of something over 800 men, whose average age was twenty-five years, and who represented eighty different daily vocations.

The Use of Conveyors in Lumbering

THE Jeffrey Manufacturing Company, of Columbus, Ohio, have installed for Lord Northcliffe, in the Anglo-Newfoundland Development Company's Mills, Grand Falls, Nova Scotia, a Jeffrey Wire Cable Conveyor line, 1,830 feet between centres. This line, which is used for delivering pulp wood to the storage, consists of a cable on the upper run and reclaimed by the return cable, which travels through a tunnel underneath the piled wood, the steel cable being 1½ inches in diameter and the flights 4 feet apart. The conveyor has a capacity of over 400 cords a day, traveling at the rate of 100 feet per minute, and is operated by a 100 horsepower engine.

"Independence" as Auto Wheel

A NEW use has been found for the Dodge wood split pulley, according to the following, vouched for by S. A. Emery, manager of the New York branch of the Dodge Manufacturing Company, who supplied the requirements:

"Recently while a large automobile was on a tour of the northern part of New York State the front wheel was broken beyond repair. A wood pulley was suggested, and this, with a bushing, was hastily secured. It was fitted to the axle, and then in place of the wheel, and under its own power, the machine was driven, with its occupants, to a railroad station some distance away, where it was loaded on a flat car and shipped to a point containing garage facilities."

Dodge pulleys are playing an important part in the manufacture of autos at the great plants of Buick, Maxwell-Briscoe, Chalmers, E. M. F. and others; but this is the first instance of where one has served as a wheel. The fact that it *filled the bill* shows how much *dependence* can be put in "Independence."

"Cost-Keeping Short Cuts"

"THE PROFITS MADE BY SAVINGS" is the title of the opening chapter of a valuable treatise on this subject just received from the Burroughs Adding Machine Company, of Detroit, Mich. "Putting in a Cost System," "Day Rate or Day's Work Plan," "Piece Work Wage Plan," "Premium Wage Plan," "Bonus Wage Plan," "Profit Sharing and Stock Distribution Plan," and "Handling the Labor Costs" are others.

The book consists of 180 pages, and is both well printed and illustrated, and goes into this most important subject very fully. It also contains descriptions of cost systems in actual use and an important chapter on "Cutting the Costs of Cost Keeping," which is a matter fully as necessary of being watched as that of the manufacturing cost itself, as many firms have discovered.

The Keller-Duplex is the name of a vacuum cleaner manufactured by the Keller Manufacturing Company, of Philadelphia, Pa. It is a machine of novel, yet not untried, construction, operated by an electric motor of only ¼ horse-power at a cost of less than four cents per hour. The Keller-Duplex Vacuum Cleaner reaches the purchaser completely assembled and mounted on its own base, no special foundation being necessary. It is automatic in operation, overloading being prevented without the aid of auxiliary mechanism, and requires no attention except oiling twice a year. It is so simple anybody can operate it with perfect results. Descriptive and illustrated catalogue can be obtained on request.

Mr. William M. Chamberlin, formerly secretary of the Detroit Adcraft Club, and promotion manager of the Detroit Lubricator Company, the Wright Manufacturing Company, and the Austin Separator Company, has recently become manager of the new bureau of general promotion of the American Supply and Machinery Manufacturers' Association. This association, officered as it is by men of prominence in the industrial world engaged privately in many large manufacturing enterprises, has grown rapidly, and is doing much good work in the field of scientific advertising. Mr. Chamberlin's long experience as a sales and advertising manager in the technical field fits him admirably for the conduct of his new work.

Addressing Machines

"THE ELLIOTT ADDRESSING SYSTEM" is the title of a handsome catalogue issued by The Elliott Company, of Boston, Mass.

Their addressing machine, now widely known and used throughout the world, was invented by Mr. Sterling Elliott while he was engaged as a publisher in the city of Boston and the first machine was shipped in July, 1900.

The book describes their machine, its design and the uses for which it is adapted, in addition to that of an envelope or wrapper addresser, such as for the addressing of bills, statements, etc. The introduction of an addressing machine into an office is not only a release from the drudgery of hand addressing, but proves a time and money saver. A great advantage of the Elliott System is the ease with which its address cards are cut, thus enabling the owner to have this work done in his own office, if so desired, at slight expense and little labor. This feature enables one to make changes of address promptly, to add new names at once before they are overlooked, and to control such changes in his address list under his own supervision, a point which has many self-evident advantages.

Mr. H. C. Horton, who for many years was connected with the *Engineering Magazine*, has become Manager of the Office Service Company, 50 Pine street, New York, N. Y.

Perfecting the High-Speed Engine "Ultimate Ideal in Engine Practice"

IN our last issue we gave a short biographical sketch of the late Charles T. Porter, who died August 29, at the ripe age of 84 years.

Mr. Porter lived to receive from the engineering profession their recognition of his distinguished services to the world.

Mr. Porter's remarkable mechanical mind left its impress on the whole industrial field.

He invented the mechanism which controls the speed of every steam engine, whether of high or slow speed, now running, and features of his design are apparent in every detail of all operating engines down to the engine bed which, under the name of the Tangye frame, is common everywhere.

The Porter-Allen engine, pioneer of high-speed engines, of which he was the father, made possible electric lighting, and is as nearly a perfect engine as was ever built, and yet, as its control passed out of his hands, he did not see it through to that state of perfection which he would have enjoyed.

He retired to his home in Montclair many years ago and the world heard little of him afterwards. But a mind which had been as active in the mechanical world as his had been could not remain dormant. And now, at his death, we find that for a quarter of a century he had been qiuetly at work perfecting the high-speed engine until he had developed what he was pleased to style the ultimate ideal in engine practice.

A few years ago he built a couple of engines to demonstrate his ideas and found that every one of his claims was realized.

Then he incorporated the Charles T. Porter Steam Engine Company and assigned to it patents which he had taken out.

The advent at this time of the steam turbine, however, which was exploited with great energy by large financial interests, caused Mr. Porter to advise the cessation of efforts to develop his project then, and he laid it away, and, owing to his advanced age, he never took it up again.

Now all his engineering papers have been looked over by his sons, who think that possibly the time is ripe, since the turbine has found its special field and there is a tendency toward a revival of the reciprocating steam engine for its legitimate sphere to bring to light the fruition of Mr. Porter's efforts.

All these papers have been placed in the hands of Mr. H. F. J. Porter, consulting engineer of this city, who, with Mr. George H. Barrus, of Boston, was associated with Mr. Charles T. Porter in the development of his ideal engine; and it is hoped that some way will be found of making available the work of so many years which Mr. Porter devoted to the subject.

Descriptive and Illustrated Book on New York Passenger Terminal and Improvements of the Pennsylvania and Long Island Railways

Westinghouse, Church, Kerr & Co. have issued a work of sixty pages and containing many fine illustrations descriptive of the New York Passenger Terminal and Improvements of the Pennsylvania and Long Island Railways. It was to this firm that the work connected with the mechanical and electrical engineering, together with civil engineering design for construction at the terminal station, was assigned. This book has a brief descriptive and historical article of the entire work as its preface, and an interesting account of the engineering work designed, supervised and constructed by them in connection with this great engineering enterprise which has now been brought to a successful finish. It also contains a large number of exceedingly good half-tone illustrations.

THE SCIENCE OF WATERPROOFING

By Edward M. Caffall

WATERPROOFING for buildings was originated by Robert M. Caffall, who was the first to perceive the properties of paraffin wax and to devise its practical application. The peculiarity about this substance is its remarkable inertness—that is to say, it has no affinity for any other substance; hence its name, derived from the Latin words "parum affinis"—"little affinity." Paraffin wax is composed of carbon and hydrogen in varying proportions, and is expressed by chemists as C_nH_{n+n+2}. To waterproof a building the following problems are to be considered, all of which are met by this process:

1. The material must penetrate deeply.

2. The color and appearance of the building must not be changed.

3. The waterproofing must be permanent—i. e., last as long as the building itself.

4. It must not be too expensive. It must be the cheapest process *in the end.*

5. It must resist alkalis, acids, gases, water, sun heat, frost and vegetable growth.

LAFAYETTE STATUE, WASHINGTON, D. C.
Recently treated with the Caffall Process, 1910.

Thus it must be paraffin and that alone, for that is the only substance that possesses these characteristics. Hence the term "waterproofing" applied to any other method is misleading, excepting when referring to underground or basement waterproofing, which is excluded from the weather. This consists in applying asphaltum and kindred substances to tarred paper, felt, etc., which is finally built upon and buried out of sight.

THE TERRACE BRIDGE, CENTRAL PARK, N. Y.

A PANEL OF NOVA SCOTIA SANDSTONE
Renovated and treated with the Caffall Process for Buildings in September, 1900.
Photographed ten years later, i. e., September, 1910.

AN ADJOINING PANEL OF SIMILAR STONE THAT HAS BEEN LEFT TO THE RAVAGES OF THE WEATHER

THE SCIENCE OF WATERPROOFING

No other substance is "'water-proof," or, more properly speaking, "weatherproof." Varnishes, washes and coatings are merely temporary, and none of them are effective, even for a short time, when applied to *damp surfaces.*

THE EGYPTIAN OBELISK (CLEOPATRA'S NEEDLE), IN CENTRAL PARK, NEW YORK,

Treated with the Caffall Process for Waterproofing by R. M. & E. M. Caffall in November, 1885, now permanently preserved from destruction by the weather.

To illustrate the truth of these statements it is but necessary to direct attention to the results of the application of Robert M. Caffall's process by his son and himself in past years. The most notable example is, of course, the Egyptian Obelisk in the Central Park, New York, treated twenty-five years ago, by which the decay of the rock was arrested, and which stands to-day in perfect condition and able to resist the weather for years to come. There are other

(Continued on page 66.)

Since Mr. Porter's article on "Industrial Betterment" appeared in last month's issue, in which he described the working of the suggestion system in a factory, he has received a large amount of correspondence from factory managers who had this system installed but were not getting thorough satisfaction from it.

He is now engaged in rehabilitating these systems on a proper footing, so that the full value of them will become available both to the management and the working organization.

Inspection Trip, North River Tunnels, Pennsylvania Railway

The Pennsylvania Railroad Company has extended a special invitation to representatives of monthly magazines to become its guests on a special train through the North River tunnels and over the Hackensack Division of their New York improvement. It is proposed to make the trip October 5, and it will without doubt be greatly appreciated by the invited guests, as it will afford them an excellent opportunity to become thoroughly acquainted with the details of the "New York Improvement and Tunnel Extension of their Road."

The "Electrification of the Cascade Tunnel of The Great Northern Railway Company," is the title of a handsome Bulletin issued by the General Electric Company, Schenectady, N. Y. The Bulletin contains many illustrations and gives very full information.

FINANCIAL NOTES OF THE INDUSTRIAL WORLD

Westinghouse Air Brake Company's Annual Report

THE annual report of the Westinghouse Air Brake Company for the year ended July 31 shows earnings of more than double those reported in the preceding year, and marks the most prosperous year in the company's history. The net earnings of $4,653,102 compare with the showing of $2,039,273 made in 1909.

After charging off $429,824 for depreciation, etc., there remained a surplus of $4,223,278, compared with $1,920,557 last year, representing 30.16 per cent. earned on the $14,000,000 capitalization, against 13.72 per cent. in 1909. The payment of $2,749,268 in dividends, against $1,374,481 last year, left a balance of $1,474,010, which brought the total surplus up to $6,931,760.

Fully Equipped Engineering Plant For Sale

An engineering plant which has been used for the production of alternating electric generators, steam turbines and other engineering apparatus, and which is fully equipped, thus enabling it to be started with practically no delay, is on the market.

Its location affords exceptional facilities, including five railway systems, as well as lake transportation, and a cash bonus from the Business Men's Association can be secured for a desirable enterprise.

As its equipment is such that it can be easily adapted to a different line of manufacturing, it affords an unusual opportunity for the industrial concern seeking a location for a branch plant, and to the newly formed manufacturing company with plant yet to be established.

Any communication addressed to H. C. H., care CASSIER'S MAGAZINE, will receive prompt attention.

Monarch Typewriter Company Reports Large Increase in Business

A straw indicating the prosperity of the manufacturing industries is the statement of the Monarch Typewriter Company that their business during the first half of September was the greatest for that period in the history of their company, and that business is showing essential increases in all sections of the country.

They state, further, that they expect the gain in sales by their New York and Chicago offices for the year will be not less than 50 per cent. over last year, and that from the present indications the sales by the Philadelphia and Boston offices will show almost as handsome an increase, while reports from other branch offices indicate a record-breaking business.

Manufacturer Wanted for Manufacture of a Moving Picture Machine

The attention of manufactories is called to an opportunity for the manufacture of a moving picture machine on an extensive scale and also for its sale. The machine is available almost anywhere, may be set up in a minute and forms an exceedingly convenient and essential piece of apparatus for every school room, club house and intellectual family in the country.

For particulars address M. P. M., care CASSIER'S MAGAZINE, New York.

Westinghouse Electric and Manufacturing Company Wipes Out Arrears in Its Cumulative Preferred Stock Dividends

A dividend has recently been declared by the Westinghouse Electric & Manufacturing Company that wipes out arrears in its cumulative preferred stock dividends since the receivership was ordered on October 23, 1907. The amount was 8¾ per cent. on the $4,000,000 preferred issue, of which 3½ per cent. is payable on October 15, at the same time as the regular dividend for this quarter of 1¼ per cent.; 3½ per cent. on January 15, and 1¾ per cent. on April 15.

Mr. John B. Milliken has accepted the position of treasurer of the Yale & Towne Manufacturing Company, with headquarters in New York. Mr. Milliken was formerly controller of the Crocker-Wheeler Company.

An Investment Opportunity

The Handy Index, established two and a half years ago, desires additional funds to enlarge its business. It wants new men as well as new money, and offers a chance for investment either with services or without. Full particulars can be obtained by addressing Mr. Hartwell Stafford, 1705-6 Tribune Building, New York, N. Y.

F. William Stocker & Co., Inc., manufacturers of waterproofing for concrete, stone, etc., report that they are doing a large amount of work for New York City in connection with sea walls, etc.

In order to facilitate the handling of their Western business, the Rockwell Furnace Company, of New York, have opened an office in the Fisher Building, Chicago, Ill., in charge of Mr. A. L. Stevens.

The contract for the Pulp Mill of the Union Bag & Paper Co., at Cap de la Magdaleine, Three Rivers, Quebec, Canada, has been awarded to Frank B. Gilbreth, Incorporated, No. 60 Broadway, New York. George F. Hardy, No. 309 Broadway, New York, is the engineer.

Industrial Sites

The sale of a number of sites for manufacturing concerns is reported by the Industrial Department of the Delaware & Hudson Company.

Extending from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines, this road provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, connecting the river with Lake Champlain, now being built by the State; it offers an establishment located in its territory the benefit of cheap fuel, electric power and low freight rates.

Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

Increased Railway Earnings

Gross receipts for the fiscal year ending June 30, 1910, exceeding those of any other year in the history of the company, increase in net receipts of $1,973,022, and a surplus of $10,776,-069, after the payment of charges, taxes and dividends paid by the Philadelphia & Reading Railway company as compared with $9,041,915 for the previous year. Such is the showing given in the thirteenth annual report of the Reading Company for the year ending June 30, 1910.

Contracts Awarded

Among recent oil furnace contracts taken by Walter Macleod & Co., of Cincinnati, are a large plate heating furnace for the J. Baum Safe Company, Cincinnati; complete furnace equipment for the Southern Motor Works, Nashville, Tenn., and a complete furnace equipment for the W. H. Clore Manufacturing Company, Washington, Ind.

THE LATEST CATALOGUES

Belts and Their Proper Care

Users of belts, the cost of which is a very considerable item of expense in shop maintenance, will find of value the pamphlet "The Proper Care of Belts," issued by the Joseph Dixon Crucible Company, of Jersey City, N. J., which goes most thoroughly into the matter of belt dressings, and contains a chapter entitled "Hints, Kinks, Tables," which is most instructive.

Patents, Trade-Marks and Copyrights

A little work issued by Victor J. Evans & Co., of Washington, D. C., contains an interesting article on the advantages of Registering Under the New Trade-Mark Law.

There are also articles treating of Copyright Law, Foreign Copyrights and Trade-Mark Patent Laws and Requirements, a table of charges for Trade-Mark Applications in Foreign Countries, as well as much information which will be found useful to those desirous of taking out a patent in the United States or in foreign countries. Copies can be obtained by addressing them.

Air Compressors

The National Brake & Electric Company, of Milwaukee, Wis., have in their Publication No. 391, entitled "Motor and Belt-Driven Air Compressors," presented in most attractive form a large amount of information of value concerning compressed air and its adaptability as an actuating medium. It describes very fully their different types of Air Compressors and Air Storage Reservoirs, including several types of Portable Air Compressor Outfits, their Combined Air Compressor and Water Pump Units.

Recording Instruments

A large and handsome catalogue on Recording Instruments is received from The Bristol Company, of Waterbury, Conn., which in all particulars maintains the high standard of all the publications they issue, a standard they have always kept of the highest order in the many kinds of recording instruments for which they are noted.

Multiple Drills, Die Sinkers, Etc.

Catalogues covering fully Milling Machines, Multiple Drills, Die Sinkers, Etc., come from the Pratt & Whitney Company, of Hartford, Conn. They are issued in the best style of the modern printing art, and contain many large half-tone illustrations with descriptive text.

Generator and Feeder Panels

A new Bulletin on "Isolated Plant—Direct Current Combination Generator and Feeder Panels" is just issued by the General Electric Company, Schenectady, N. Y., superseding previous Bulletins.

Superheaters and Feed-Water Heaters

"Smoke Box Superheaters and Feed-Water Heaters" is the title of a catalogue received from the Baldwin Locomotive Works of Philadelphia, which contains an article on the former by Mr. John W. Converse, and one entitled "The Advantages of the Use of Moderately Superheated Steam in Locomotive Practice," by Lawford H. Fry. A copy can be obtained by addressing the company.

Leather Splitting Machines

The American Tool & Machine Company, Boston, Mass., presents a well-designed and executed catalogue giving typical illustrations of their Belt-knife Leather Splitting Machines, as well as their duplicate parts. The book contains a number of illustrations of a high order.

Bearings and Friction Clutches

Among other catalogues issued by the Hill Clutch Company, of Cleveland, Ohio, are ones on Bearings, Friction Clutches and Transmission Machinery. This company is noted both for the attractiveness and value of its publications.

Steam Hammers and Milling Machines

The Niles-Bement-Pond Company issue a valuable catalogue of 52 pages, 9 x 12, with many illustrations of the Bement Hammer they manufacture, and a similar one treating of Heavy Milling Machines. These catalogues are well worth owning and can be obtained on request.

Electric Heat in Hat Manufacture

A pamphlet, entitled "Electric Heat in the Manufacture of Hats," just issued by the Westinghouse Electric and Manufacturing Company, is another indication of the almost unending uses electricity is being put to. The pamphlet is very fully illustrated and of much interest.

Autogenous Welding Equipments

Autogenous Welding Equipments Compared, a Discussion of the Relative Merits of the High and Low Pressure Systems, is the title of a leaflet just issued by the Davis-Bournonville Company of New York. It is interesting reading, especially that portion of it treating of the welding of Edison storage battery jars mechanically. Copies can be obtained from them on request.

Hawthorn Electric Motors

A booklet giving information concerning the Hawthorn electric motor, and showing the many uses it can be put to, is issued by the Western Electric Company, of New York, N. Y. A copy can be obtained by writing them.

Brush Balanced Engine and Direct-Connected Lighting Set

Complete illustrated catalogue issued by the Chas. A. Strelinger Company, Detroit, Mich., describing the Brush lighting set, which is portable and compact, and their many other products. A sketch of the work of Alanson P. Brush is also given.

Dodge Handy Calculator

The Dodge Manufacturing Company, Station H-H, Mishawaka, Ind., have issued a useful Calculator for pulleys, belts and friction clutches. It is bound in real leather, and will be sent by them on receipt of 25 cents.

Cold-Drawn Steel Tubes

The National Tube Company, of Pittsburg, Pa., are issuing a set of most artistic desk blotters, the face of which is devoted to the history of seamless steel tubing, etc. They are interesting and useful. Copies can be obtained on request.

Waterproofing

"Some Facts in Regard to Waterproofing" is the title of a valuable pamphlet issued by the Hydro-Bar Waterproofing Company. It is interesting reading, and a copy can be obtained from F. William Stocker & Co., Inc., 34 West Thirty-third street, New York.

Automobile Trip Records

The B. F. Goodrich Company, of Akron, Ohio, have just issued a second edition of "A Memory of Motor Yesterdays" for use in keeping record of automobile trips. A copy will be sent by them on request.

The Utilization of Natural Resources

WE have heard much talk of late about the conservation of natural resources, and the subject has entered into politics, business and engineering, sometimes with but scant indication of a reasonable conception of the real meaning of the term. Some writers appear to understand conservation in the same sense as the miser regards the care of his material wealth, and consider it as equivalent to the jealous hoarding of natural wealth, wealth which can be of value only when it is being used. Others, with a more rational conception of the idea, regard conservation as practically synonymous with rational utilization, with the reduction of waste to a minimum, and the development of serviceable value to a maximum, and the intelligent engineer has always regarded the wise use of the resources of Nature in this light.

Assuming, then, that conservation is best attained by the reduction of waste and by the creation of value, it may be worth while to consider wherein the work of the engineer may best be directed to attain these ends. Martens has divided the materials of engineering into two classes, materials of construction and materials of consumption, the latter class including those substances which, in being used, are practically consumed and transformed so as to be incapable of further use, such as coal and other fuels.

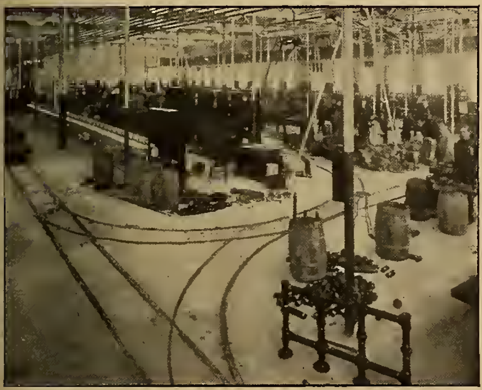
In considering the methods of conserving such materials, it is well to examine wherein the possible wastes now exist, this indicating to the engineer the lines along which his efforts may best be directed.

Such an investigation shows that before a material can be utilized at all it must, in nearly every case, be transported from its natural situation to some other point, so that a value is given to it without any material change other than that of location. This means that one of the great opportunities for conservation lies in economy of transport, or rather in the losses which accompany transport. Poor Richard said that "three removes are as bad as a fire," and although he was referring directly to household belongings, the same principle holds good with respect to other materials, and ordinary methods of transport are always accompanied with losses, greater or less, according to the method used.

Leaving aside the possible improvements in long-distance transport of material, we find a great opportunity for economy, not only in time and cost, but also in waste, in the use of the latest and best appliances for handling. The coal which is lifted from car or barge into elevated bins by modern machinery suffers far less loss and waste than if shoveled by main strength from one point to another in succession. When, again, the coal descends through properly designed chutes to the mechanical stoker by which it is fed to the furnace the losses are again reduced to a minimum. The old-time institution of the "long" ton was simply an allowance for the assumed inevitable losses in handling, so that the "hundred-weight" of 112 pounds simply meant an addition of 12 per cent. for wastage. If 12 per cent. of the coal bill of the world could be saved, as most of it can, simply by the avoidance of handling losses, far more will have been done toward true conservation than all the efforts to keep the coal in the ground and prevent its use until future generations appear.

Other methods of aiding in the good work of conservation appear in the application of effective methods of combustion, of smoke prevention and of maintenance of high efficiency in boilers and engines, but these belong to another field. It is evident, however, that conservation, from the viewpoint of the engineer, means reduction of wastes; it means the direction of the great sources of power in Nature to the *use* and convenience of man," and in these words it was broadly set forth by Tredgold nearly one hundred years ago.

A Paying Investment Hunt "Industrial" Railway



No. 0994.—Machine Shop and Shipping Department, Utica Drop Forge and Tool Co , Utica, N. Y.

will reduce the pay roll more than any other system.

One company installed this system and their pay roll was reduced $24 per day and in addition the capacity was increased.

Simple to install, as an ordinary workman can lay it down.

MAKES every corner of the works or factory accessible. The gauge is 21½ inches and it can be laid within the standard 4 ft. 8½ in. track, without cutting or notching the rails. Made up in four styles:

Riveted up track with malleable iron cross ties.
Riveted up steel track.
Knock-down track.
Cast Plate track.

Everything for use with this system is kept in stock for immediate delivery. : : : :

If the necessary data is sent, we will prepare a lay-out without charge and with the right cars will show where this saving can be effected.

Hoisting and Conveying Machinery, Cable Railways, Automatic Railways, Steam Shovels

No. 008.—Standard Cars. We Design Cars to Meet Any Special Requirements.

C. W. HUNT COMPANY

Established 1872

West New Brighton, New York

New York City, 45 Broadway — Richmond, Va., State Bank Building — Atlanta, Ga., 607 Rhodes Building
Chicago, 1616 Fisher Building — San Francisco, 865 Monadnock Building

Lightening the Burden

IN viewing many of the works of antiquity the fact that strikes the traveler most forcibly is the vast amount of physical strength that was expended to accomplish the wonderful results attained. In the days when mechanical aids for such purposes were not only few, but of a most primitive nature, one can imagine the great number of both men and animals required by the ancients to lift into place the stones of the Pyramids and of the Colisseum.

Yet even in these modern days, when so much has been done to lighten the burden for both man and beast, there are many tasks performed by the use of much unnecessary physical effort and even brute strength, for no better reason "than that they have always been done that way," when by the application of devices well known and largely used in other lines of work they could be accomplished with far less effort, time and expense.

A good illustration is the amount of human effort and muscle still misused for the direct lifting of heavy weights in many every-day occupations. There is no class of work carried on to-day where the occasion does not demand the safe, quick and economical transportation of heavy objects, while often the method pursued in accomplishing such work is not very far advanced over that of the ancients.

For example, the farmer equipped with ordinary pulley block and tackle, assisted by his hired men and horses, struggling and straining to lift a heavy stone on his stone boat and to place it in his wall.

This was well enough in the "good old days," when labour was cheap and competition did not mean that time and effort wasted were money and opportunity lost.

The managers of modern machine shops and manufactories where every effort is made to perform work along the line of least resistance are well aware of the value, for instance, of such a device as the Triplex Block, and its extensive use has either caused the old-time labouring gang to disappear or to be greatly reduced in numbers. Such, however, does not hold true to the extent it should in many other lines of work where its introduction would work changes of the greatest value, not only in the saving of time and money, but in the health and happiness of mankind.

By the use of such a device as the Triplex Block in the many ways it could and should be employed, ways that are in fact universal, loads that now call for many men could be safely and economically raised by one, and not only lifted but automatically held at any point, for any time desired, as well as moved horizontally in any direction, and if necessary lifted and lowered to just the right height by the same man without other human aid.

In fact this block multiplies the strength of one man to such a degree he is the master of any lifting problem, with a return of fully 80 per cent. of useful work for the labour he expends.

When it is realized that with the ordinary hoist only about one-half of the effort expended by the operator is returned in actual results, the introduction of such a device as the Triplex Block into the large number of every-day uses for which it is so well adapted increases the efficiency of the same man 80 per cent., the full value of its introduction is easily appreciated, and it is safe to predict that in a short time even its present wide use will be largely extended.

It is not alone through the efforts and inventions of the engineer that life is made more pleasant and results are now accomplished at a much reduced expenditure of money, time and physical strength, but it is the further extension and use of the practical and efficient creations of his brain that his labor is year by year doing more and more to lighten the burden for all mankind.

THE SATURDAY EVENING POST *September 17, 1910*

Aerial Transportation

The Triplex Chain Block

The best chain hoisting machine, absolutely *safe*. Always holds the load automatically at any point. One man alone can lift the full load

THE lifting of loads is a universal need—a vital factor in every man's business. The Triplex Block is the simplest, safest, most efficient and most economical load-lifter in the world.

It lifts loads under all conditions in all places—from a palace to a sawmill—a garage to a warship.

When one man pulls on the hand chain of the Triplex Block, he can lift any load from 200 lbs. to twenty tons; two men can lift forty tons.

The load is always automatically held at any point during the lift. You can go away and let it hang ten seconds or a year. It will not come down until you are ready. Then you lower it by pulling lightly on the reverse side of the hand chain.

The Triplex Block has the strongest, simplest, smoothest-running, wear-resisting system of gears ever devised to multiply lifting power.

It so multiplies the strength of one man as to make him master of every lifting problem.

Many loads must also be transported—moved horizontally. The Triplex Block not only lifts its load easily and holds it suspended safely, but when hung from a trolley running on an overhead track, the load may be moved easily wherever the overhead track goes.

One man can push the load as easily as he lifts it.

In foundries, machine shops, factories, sawmills, mines, quarries, warehouses—in power-houses and boiler-rooms—on railways, ships and docks—thousands of Triplex Blocks are daily lifting and transporting thousands of tons, at a saving in labor which frequently repays the whole cost of installation in six months. Everyone who has lifting and transporting to do should write for the book about Triplex Blocks. A postcard brings it.

Three hundred dealers in the United States carry Triplex Blocks in stock. Wherever you are and whatever your problem—you may have a Triplex Block to try by just asking any one of them or by writing to us.

14 Sizes: One half a ton to forty tons.

The Yale & Towne Mfg. Co.

Makers of Yale Products
Locks, Padlocks, Builders' Hardware, Door Checks, and Chain Hoists.

YALE

9 Murray St., New York
Chicago, Philadelphia, Boston, San Francisco, London, Paris, Hamburg

Loading or Unloading

With a Triplex Block working on a projecting length of trolley track as in the above illustration, one man can load and unload blocks of stone, boxes or castings up to twenty tons in weight.

In a Warehouse

With a simple frame work and a Triplex Block suspended from the top and hooked to the car one man can put up or take down a barrel full of oil in two or three minutes.

On a Farm

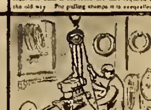
One man alone, with a Triplex Block, can put the heaviest stones on his stone-boat and build them into walls in one-tenth the time required in the old way. For pulling stumps it is unequalled.

On Board Ship

With a Triplex Block swung from a ship's davit, as shown in the illustration, one man alone can hoist aboard the full load that the davit will sustain.

In a Boiler Room

With a Triplex Block hung from a trolley and running on an overhead track, one man can handle more coal and ashes in an hour than the man with the wheelbarrow can handle in a day.



In a Garage

With a Triplex Block hung from a trolley, one man can not only lift the whole car,—the chassis, engine or gear-case—but he can move them wherever he likes.

The Triplex Block would prove itself a real necessity in thousands of places where it is not even known today.

This is why we spent $3,000 to print the above full-page advertisement in the Saturday Evening Post of September 17th.

Force and Motion

IN the discussion of the performance of work by mechanical power the engineer finds himself facing the question of accomplishing two things: one, the production of sufficient force to overcome the resistance opposed to him; the other, the imparting to this force of the motion necessary to keep up a continuous action. A force of 100 pounds can do no work until it is given a velocity, until it is made to travel a given number of feet per second, until it is converted into *foot-pounds*.

A natural consequence of these facts is that it matters but little, at least theoretically, which of the two elements is the larger; we may have a few pounds moving very rapidly, or a larger force moving proportionally slower, and the amount of power developed will be the same. The whole history of engineering has shown the development from the heavy, slow-moving force to the lighter, high-speed combination, a natural consequence of the improvement in constructive possibilities.

Thus, in the earlier days of mill construction it was thought possible to transmit power only by heavy, slow-moving shafting and gearing, and the use of belting and pulleys was considered trifling, and adapted only to very light machinery. The moderate frictional hold of the belt upon the pulley and the correspondingly lower strength of the belt, as compared with the ponderous cog-wheels, led to such conclusions, until it was realized that the greatly increased speed of the belt enables ample power to be transmitted; it was the same combination of force and motion, and if the force was smaller the motion was faster, and the power transmitted was as great in the one case as in the other. When, still later, it was proposed to use rope driving for many purposes, the same misconception stood in the way, and the old-time machinist, who laughed at the idea of attempting to drive his lathe with a "piece of string," opened his eyes when he saw that the swift-running rope could pull him through a cut which had caused the old belt to leave the pulley many a time. To-day these things are better understood, and with the development of the science of the transmission engineer it has been found possible to meet almost every demand, and to deliver power to any point where it is needed with certainty and efficiency. The result is a rapidly extending use of power for many purposes for which it was formerly considered inapplicable. In every part of the shop, power is readily attainable, whether delivered by belt, rope or electric wire. Men use their brains to direct their hands in the guidance of power-driven tools for nearly every operation, with a resulting increase in capacity and efficiency beyond estimate. What the development of modern railway transport has been to the expansion of commerce, the increase in power-transmission facilities has done in the manufacturing industries. The development of mechanical force would avail nothing if with it there had not come a similar development of appliances for providing the motion necessary to complete the production and delivery of power.

It is never safe to predict the limitations of any department of industry, but one has only to look back at what has been accomplished in the comparatively few years since really effective power transmission has been accomplished to realize the possibilities in the immediate future. There is no reason why human labor should be called on for the performance of any severe effort, since there may always be mechanical power available and convenient. The idea that there is a certain dignity essential inherent in the exertion of muscular effort was once considered evident, although with it went the belief that the burden of labour was instituted as a punishment. If the latter view be accepted, man is working out his deliverance through the efforts of the engineer of power and transmission.

DODGE

The Dodge Line Means Standardization

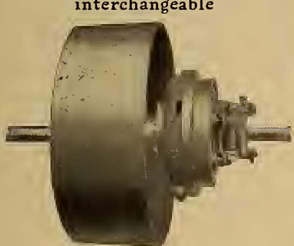
IN the best equipped, most efficient plants all over the country, where the value of standard equipment is appreciated—

¶ There you will find The Dodge Line of Power Transmission Machinery installed throughout.

¶ Please note the advantages these plants have secured.

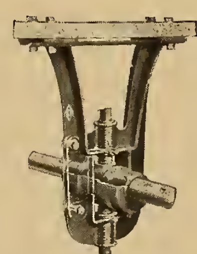
¶ The Dodge Line represents The Dodge Idea—Standardized excellence and interchangeability and the split feature in power transmission machinery.

Dodge Split Friction Clutch with Iron Pulley. Mechanism and Pulley are separate and interchangeable



Dodge "Independence" Wood Split Pulley. For twenty-eight years the standard, economical pulley for shop work.

Dodge Adj. True Ball and Socket Hanger, with four types of self-oiling bearings.



¶ The adoption of one complete line of such transmission appliances means quick installation, low cost of maintenance and attendance, and economy of operation.

¶ That is why The Dodge Line would be profitable as *your* shop standard.

¶ Let us advise with you in regard to transmitting power at your plant. Your name on the coupon brings our new general catalog No. CC-10, "Power Transmission Engineering," just out, and other interesting information.

Dodge Manufacturing Co.

STATION J-11, MISHAWAKA INDIANA

New York Chicago Boston Cincinnati Brooklyn
St. Louis Pittsburg Atlanta Philadelphia Minneapolis

Agencies in most other cities in the United States

DODGE MFG. CO.
Station J-11,
Mishawako, Ind.

Please send your New Catalogue CC-10 to

....

Position ....

Firm ....

Town ....:State ....

Radialaxe Possibilities

THE Radialaxe principle would seem to be generally and widely applicable to operations in stone excavation, the working in fixed planes being dictated not only by the natural cleavage of the rock, but also by the planes which usually are required by the shapes of the finished blocks for building, monumental or other uses. As generally happens in the development of inventions, what is most obvious in the retrospect is delayed in its first inception until the less serviceable devices, each an improvement upon its predecessor, have been successively worked out and their deficiencies, as well as their possibilities, revealed. The Radialaxe is comparatively a newcomer; we may easily believe that all the possibilities for its employment and the advantages of it have not yet all been developed, and we may expect its more extensive employment in the future.

The Radialaxe comes along naturally as the successor and working companion of the stone channeler. The latter may be said to work normally with vertical bits or cutters, the cut being in a vertical plane, permitting liberal angular departures from the vertical in either direction of working, while the normal working of the Radialaxe would, perhaps, be difficult to define.

The normal working direction for the bit of the Radialaxe might, perhaps, be said to be horizontal rather than vertical; but from this normal or central direction it would change constantly when working in a vertical plane; but it would work as well in a horizontal plane, and when so working the lateral direction of the cutter would be as constantly changing. From either the vertical or the horizontal plane of working the Radialaxe operates with equal facility at any required angular pitch in either direction.

It not only carries cutters whose function is the same as that of the stone channeler, but it also works as a regular rock drill, putting in holes in any direction and to any required depth for blasting. It is quickly and easily adjusted for working in any direction and for either channeling or drilling, and the parts of the apparatus are easily separated into convenient weights for handling.

The special characteristics of the Radialaxe peculiarity qualify it for the variety of operations involved in the work of the coal mine, although the principal operation is a species of rough channeling in directions paralleling the strata, which seldom vary far from the horizontal. This horizontal working will consist of undercutting the seam so that the coal can be easily broken down, the most persistent operation of coal getting, or of cutting out of bands of clay, which often occur in the middle of a seam and seriously impair the purity of the coal if not removed. Especially in this latter case some precision of location is required, with the greatest facility of movement, so that time will not be wasted; and in this the Radialaxe would seem to have it practically all to itself.

For the vertical channeling, if we may so call it, which occurs in coal getting, for entry driving, for shearing on either side in the rooms, or for center cutting, so that light shots will bring down the coal in large lumps and with the least shattering of the walls, the Radialaxe again approaches the ideal.

Each coal mine is different in some respects from every other, and the work of getting out the coal as cheaply and in as good condition as possible will vary in essential particulars. The most desirable characteristic of a machine for which a market may be expected must be adaptability, a readiness to work in all positions, in widely varying conditions, and to turn itself from one style of cutting to the other, as required, and for this the Radialaxe is eminently adapted.

Advantages of Concrete Construction

NEARLY every type of building-construction has its special advantages; properties which have been developed in the course of long periods of use, or else qualities inherent in the material itself. The combination of cement, sand and broken stone, called concrete, and really being artificial stone, manufactured in place, and moulded to suit the location as a building material has its properties and advantages, some of them peculiarly its own and some acquired by the application of technical ingenuity to meet the requirements of the case.

It is no small advantage, in the first place, to be able to manufacture stone of just the dimensions required without being obliged to have recourse to the slow, difficult and expensive expedient of cutting it to suit. The possibilities of wooden forms, to be filled with the semi-liquid mass, setting and hardening into permanent condition and rapidly becoming as durable as natural stone itself, form by no means the least of the advantages of concrete. Given the massive walls and solid partitions, and there comes with them an idea of permanence wholly lacking with a timber house, however artistic. Destruction by fire is a practical impossibility; the material has been through the fire already and is immune. The annual painting demanded by a well-kept wooden house, with its accompanying annoyances and expenses, is unknown with the concrete building, which needs no more attention in this respect than one built of stone. The general advantages of concrete construction have now become so well established that architects have its opportunities and facilities well in hand, and instead of the earlier and cruder designs have produced many most effective buildings, adapting the plan to the material and combining effective appearance with the capabilities of the substance itself.

An essential advantage of concrete construction, and one which, while not inherent in the material, has been very successfully developed to meet an important demand is its waterproofing. Concrete in itself is not entirely impervious to water, and although it can be so made as to resist water pressure most effectively, it cannot be considered damp-proof unless made so by special treatment. The demand for absolute waterproofing of concrete, however, has led to the development of processes which attain this end completely, and thus there is added to the natural advantages of concrete the artificial advantage, so to speak, the result of the art of the engineer and technologist, of resistance to damp and to the penetration of moisture.

Under such conditions it is evident that concrete, either plain or reinforced, is bound to become the dominant building material, and that it will gradually supersede timber, stone or brick, for many purposes. With the increasing scarcity of lumber, and its consequent increase in price, the question of cost will continue to be in favor of concrete, while the abscence of maintenance expense must be added to the balance on the side of the concrete building.

Probably the greatest advantage of concrete, however, and one to which allusion has already been made, is the freedom from fire risk. The fire losses in the United States have been estimated as reaching about $2.50 per year for every man, woman and child in the country, a tax which, if imposed by legislation, would meet with such opposition as to insure its prompt repeal. It is within the power of the citizen to remove this burden without political or other agitation, simply by insisting upon the use of non-combustible material for all purposes, and when it is realized that with this attainment of freedom from fire risk there are acquired the other advantages already enumerated there should be no question as to the result.

The Science of Waterproofing

(Continued from page 51.)

examples not so well known which are even more remarkable. In 1868 a church window and gable end at Thedden Grange, Shalden, Hampshire, England, were treated, because of bad leaks in storms. This gable end, examined recently, presents a fresh, clean, sound appearance, while the rest of the stone is covered with lichen and rotting away. A hop-kiln at Alton Hauts, England, treated the same year to keep dampness out of the kiln-dried hops, is still dry; moreover, water poured on the treated surface rolled off without being absorbed. Here are tests of *forty-two years* and no change apparent. Equally striking are some examples of more recent work. The pillars of St. Bartholomew's Church, Forty-fourth street and Madison avenue, were procured from Italy some seven or eight years ago. The violet and green tones of this delicate marble give an effect to the building not to be matched in the city. But the weather so quickly attacked the stone that pieces began to flake off and the entire surfaces of the pillars became roughened and deeply pitted by decay. Edward M. Caffall undertook the renovation of the columns and their preservation by waterproofing. The result is astounding to those acquainted with the former conditions. By this means the architect has been justified in his selection of this stone for his color scheme, because it is now enduring as well as beautiful. It is apparent that science and skill are requisite in the treatment of buildings when permanence of result is desired, and this is true of even new erections. New problems are presented, however, when the stone or brickwork has been injured by weather exposure, and these must be met and corrected *before* waterproofing can be proceeded with. Hence the absurdity of selling so-called waterproofing compounds in bulk to be applied by unskilled labour, ignorant of the fundamental principles of climatic attack. Disappoinment is inevitable, and the expense might better be spared. As a matter of fact, much greater damage ensues in the majority of cases.

It has been estimated that the loss to buildings by weather and smoke damage in the United States amounts to no less than $500,000,000 annually. The loss caused by damage to marble monuments, many sculptured by eminent artists, can never be estimated. Statues of Washington and other great men, left unprotected, have been irretrievably ruined. Monuments are interesting to the public when original. Reproductions never satisfy. The first question asked by the average visitor to a cemetery is almost invariably: 'Which is the oldest stone?" No matter how small or quaintly lettered, the chief interest centers around that early memento. Let the visitor to Trinity Churchyard, New York City, compare the tombstone of Charlotte Temple with that of William Bradford, printer. The Temple stone is the original and arouses interest, while the Bradford stone replaces an original, and a feeling of regret and disappointment is inevitable. The worst example of this feature is to be seen in Windsor Castle, England. The original Curfew Tower, erected by William the Conqueror, was recently stripped of its outer stonework and a coating of new stone built all over. Not a particle of the original walls can now be seen. The visitor is looking, apparently, at a brand-new building. The effect is deplorable. Imagine the Obelisk in Central Park dressed down and new hieroglyphics cut or thin slabs of stone built around it! The marble statue of Washington that stood in front of Independence Hall, Philadelphia, was lately taken away because of the fearful damage wrought by the elements. A bronze reproduction of modern manufacture has taken its place. Many years ago the authorities were warned of its condition and urged to preserve it, but the warning was unheeded till too late.

Manufacturing News

The Motor and the Aeroplane

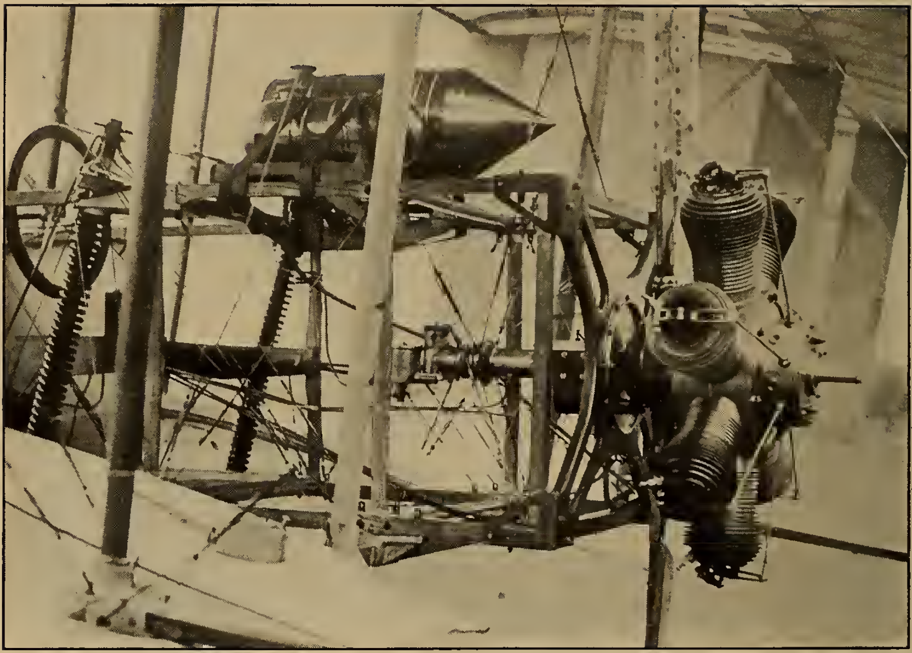
IT was the motor and the man that did it! On April 27 and 28, 1910, there occurred what must ever be considered as an epoch-making event in the hstory of applied science; Louis Paulhan, in a Farman aeroplane propelled by a Gnome motor, flew through the air from London to Manchester, a distance of 186 miles. It is now well known that the motor is the thing which makes for success in the conquest of the air. The Wright glider did very well without a motor; but had not the motor been available, its range would have been forever limited to a few hundred feet. The work of Daimler, in reducing the weight and increasing the power of the gasoline motor, made the automobile a possibility, and the development of the automobile motor provided the light-weight, high-power machine which was to propel the planes of the flying machine through the air.

The water-cooled motor is too heavy, with its burden of cylinder jackets, radiator and cooling water; but these defects have been overcome, and the Gnome motor, with its seven revolving cylinders, whose thin, projecting ribs whirl through the air and permit the rapid and effective transfer of heat from the intense combustion within to the swiftly passing air currents without, needs no cooling water and no radiator, and affords the latest example of concentration of power generation by the combustion of liquid fuel.

The machine which made the flight from the metropolis to the manufacturing centre is clearly visible in the illustration, which shows a 50 horse-power Gnome motor, weighing only 167 pounds, or 3.34 pounds per horse-power, identical with the machine which carried Paulhan from London to Manchester in twelve hours, including the single stop for fuel, and which enabled him to make the last twenty-four miles of the flight in twenty-four minutes.

The sound principle for the construction of a light-weight motor, that it should be light by its own design rather than light in its parts, has been well observed in the Gnome motor. None of its parts is made of cast metal, and no aluminum is employed in its construction.

The extreme lightness secured has been obtained by the correct distribution of the materials, thus securing the maximum degree of efficiency in resistance. Most of the parts are made of forged nickel-steel, and quality is held above all things. Unlike other motors in which there is a revolving crankshaft, the crank remains stationary, and the seven cylinders and the crank chamber revolve, thus bringing the cooling extended surface of the ribs continually in contact with the air, besides forming



THE GNOME MOTOR ON THE PAULHAN AEROPLANE

a powerful fly-wheel, maintaining steady motion, and securing perfect balance. Through the hollow axle comes the combustible of air and vaporized fuel, as well as the oil for lubrication, and at the extremity of this shaft is the carburetor, which converts the gasoline into gaseous fuel for combustion.

This set of cylinders revolves at a speed of 200 to 1,300 revolutions per minute, and a horse-power-hour requires about 300 grammes, or 10.58 ounces avoirdupois, of petrol. Taking the calorific value of this fuel at 20,000 British thermal units per pound, we have, for 10.58 ounces, or 0.661 pound, a consumption of 13,220 British thermal units per horse-power, corresponding to an efficiency of nearly 20 per cent.

It is well understood that economy of fuel is as important as reduction in weight of the motor for an aeroplane, since with the increasing lengths of flights the weight of fuel to be carried becomes more of a burden than the motor itself. Thus, a 50 horse-power motor, consuming more than 30 pounds of fuel per hour, would require about its own weight in petrol in a flight of three hours, and thus anything which diminishes the fuel consumption increases the flying radius in proportion.

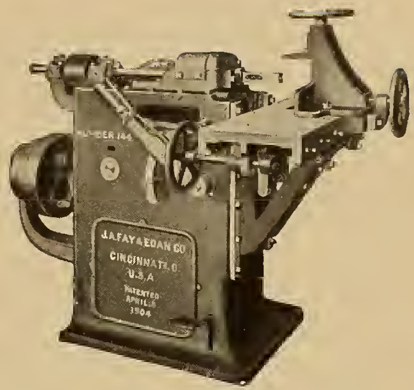
The question of aerial navigation has been taken out of the experimental and sporting stage and made an engineering and commercial proposition. It is a matter for the engineer, and to him the aviator must look for the improved motor for details of construction and for materials of greater strength and less weight. The fact remains uncontested; a man, in a mechanically-propelled machine, has occupied the third dimension, and above the surface of the earth has outdistanced the swiftest railway train.

Four-score years ago the Rocket made its marvelous run of 35 miles an hour on the beginnings of the Liverpool & Manchester Railway, and George Stephenson "at last deliv-

ered himself." It took but a few years from that demonstration to the full fruition of the steam railway, an engineering achievement which has transformed the surface of the earth.

Now the engineer has gone above the surface, and to that same city of Manchester has gone the demonstration of the assured navigation of the air over nearly two hundred miles. How soon it will be followed by the commercial realization remains to be seen, but we have before us the precedent of the railway; and things move to-day with an accelerated progress.

An Automatic Hollow Chisel Mortiser



NO. 144.—AUTOMATIC HORIZONTAL HOLLOW CHISEL MORTISER.
Made by J. A. Fay & Egan Company, Cincinnati, Ohio.

This new automatic, horizontal, hollow chisel mortiser is designed for a great variety of light and medium grade of work in carriage and wagon factories and is presented to the trade with confidence and assurance of an up-to-date tool.

The capacity of the machine is 8 inches wide by 8 inches thick, and it will mortise from ¼ inch to 1½ inches square, and to the depth of 7 inches.

The manufacturers claim special merit for this machine because of its convenient adjustments.

The reader will note from the illustration that all the adjustments are within easy reach of the operator.

In the manufacturer's new illustrated circular special attention is called to the following features:

Column is a single-cored casting, very heavy and with broad, continuous floor support.

Table is 40 x 8¾ inches, is counterbalanced, and has vertical adjustment of 8 inches, by means of a lever provided with stops to permit of making double or triple rows of mortises in same line. It has an adjustment endwise, with suitable stops for regulating the length of mortise by hand wheel, rack and pinion, as illustrated.

Chisel is fixed to a reciprocating frame moving in planed ways on the top of the column. It is driven by elliptic gears and has quick return at the completion of the mortise. Three speeds of feed to ram to allow for wide range of sizes in chisels and hard and soft woods.

Foot treadle at the base of the machine governs the chisel thrust. The stroke of the chisel is variable by changing the crank pin on the crank arm. The depth of mortise is regulated either by the adjustment of the table or the adjustment of the stroke.

For further information those interested should write the manufacturers, J. A. Fay & Egan Company, 226-246 West Front street, Cincinnati, Ohio, who will be pleased to send full particulars.

Mr. J. B. Comstock, for six years with the Westinghouse Electric & Manufacturing Company at its East Pittsburg works, and for four years manager of its publication department and printing plant, severed his connection with that company in April, to accept a similar position with the P. & F. Corbin Company, of New Britain, Conn. Prior to Mr. Comstock's connection with the Westinghouse Company he filled the same position with the Corbin Company that he has recently been recalled to assume.

News Items

Mr. Henry D. Shute was appointed to the position of acting vice-president of the Westinghouse Electric & Manufacturing Company, as of April 1, 1910.

For seventeen years Mr. Shute has been associated with this company, and his promotions, from time to time, have been of a character to give him a broad experience in shop, sales and executive work.

Mr. Shute studied electrical engineering at the Massachusetts Institute of Technology, from which institute he was graduated in 1892. Following his graduation, he spent a year's study in Germany at the School of Mines, Clausthal, and also in Dresden. It was in 1893 he entered the works of the Westinghouse Company at Pittsburg as an apprentice, spending his first two years in the testing department, following which he spent considerable time on erection work, on laboratory work, under Mr. C. F. Scott, and later as assistant foreman of one of the departments of the works. This naturally gave him a broad experience in shop work, which, with the designing work on alternating-current apparatus, which he subsequently took up in the engineering department, enlarged his experience still more.

After five years' service with the company, Mr. Shute took up work in connection with the sales department at the East Pittsburg office, and in 1901 was made the head of the alternating-current division, correspondence department. Two years later he was advanced to the position of assistant to Vice-President L. A. Osborne, which position he held at the time of his recent appointment. In this latter position he was active in the developments made in heavy electric traction and, particularly, in single-phase railway work.

Mr. H. F. Stimpson, consulting engineer, 1 Madison avenue, has removed his office to Suite 1005 Singer Building, having become associated with the Universal Audit Company as its chief engineer, in charge of the design and development of, efficiency in industrial plants.

Mr. Stimpson has had a wide experience as an engineer, extending over more than twenty-eight years, having been previously connected with many large organizations, among which are the General Electric Company; Dodge & Day, engineers, Philadelphia; The Roberts & Abbott Company, engineers, Cleveland, Ohio, and The Emerson Company, efficiency engineers of New York. He is also one of the lecturers in the very advanced course in manufacturing plant design at Columbia University.

The general manager of the Universal Audit Company, Mr. W. M. Williams, has had a wide experience in the organization of industrial corporations, gained by association with men engaged in the formation and successful management of several large enterprises, among which were The American Steel & Wire Company, The American Steel Hoop Company and The American Can Company.

This organization, which has a capital of $150,000, is unique in that it is the first one to cover the entire field of commercial and technical organization and service required by present-day industrial concerns, and to so combine the financial and economic accounts with efficiency standards as to demonstrate the efficiency of the management, together with obtained financial results. Such presentation is invaluable to those seeking to increase capitalization.

Mason & Hanger, contractors for one of the siphon tunnels on the New York water supply extension, are installing in their plant at Cornwall, N. Y., two large Ingersoll-Rand Corliss duplex air compressors, with a capacity of 5,200 cubic feet

per minute. These machines have cross-compound Corliss steam cylinders and cross-compound two-stage air cylinders. They are of the enclosed dust-proof, flood-lubrication type designed for high-speed operation at air pressure of 80 to 100 pounds. These contractors have also placed an order for a full equipment of Ingersoll-Rand rock drills, mountings, steels, etc., for carrying on their work.

Mr. L. J. Wing has recently resigned as president of the L. J. Wing Manufacturing Company, and Mr. E. D. Fieux has been elected as president of the company, Mr. C. E. Cole as vice-president, and Mr. H. S. Wheller remains as secretary. Mr. Wing still remains a director and stockholder of the company and will devote considerable time to its interests.

The White Fireproof Construction Company has removed its New York offices from No. 1 Madison avenue to larger and more commodious quarters at 286 Fifth avenue.

Charles T. Jeffery, who for sixteen years was a partner with his father, the late Thomas B. Jeffery, in the firm of Thomas B. Jeffery & Co., now assumes complete control of the manufacture and sale of Rambler automobiles.

Mr. Jeffery is widely known in the trade, having contributed much to the development of the automobile industry since its inception.

It is announced that the business of Thomas B. Jeffery & Co. will continue without change in policy.

The Kerr Turbine Company of Wellsville, N. Y., has arranged for representation in two more American and three foreign cities as follows: San Francisco and Oakland, Cal., United Iron Works; London, England, Economical Gas Appliance Construction Company, Ltd.; Mexico City, J. H. Bloomberg; Sidney, N. S. W., A. F. Partridge.

With the above the Kerr Turbine Company now has active representatives in twenty-six cities. The use in Europe of American turbine units of the small sizes built by this firm would hardly seem to warrant representation on the other side, but numerous Kerr turbines have been sold in England alone, one customer there having bought seven on repeat orders.

Two Westinghouse low-pressure steam turbines, each having a capacity of 500 kilowatts, have been added to the power plant of the Standard Steel Car Company, at Burnham, Pa. These turbines utilize the waste steam of the main equipment, and are designed for a vacuum of 28 inches, which will be provided by Westinghouse-Leblanc condensers. The energy thus conserved is applied to two 500-K.W. generators which furnish light and power for the shops.

As a steam auxiliary to its new water-power station, the White River Light & Power Company, Noblesville, Ind., is adding a 300-kilowatt Westinghouse high-pressure steam turbine set. The new unit will be installed at the generating station, two miles above Noblesville, on the White River, furnishing three-phase, 60-cycle power at 2,300 volts for lighting and power in the city. The turbine is to operate at a steam pressure of 150 pounds, exhausting into a vacuum of 28 inches. Four hundred horse-power of Babcock & Wilcox boilers are installed, using Indiana slack coal at $1.75 per ton. The economy of the turbine equipment makes it a comparatively inexpensive auxiliary of the water-power apparatus during the variation of flow in the course of water supply. The water power installation of the White River Company was only recently completed, and has taken over the furnishing of electrical energy to the local lighting and power consumers.

The Art of Making Violins

DESPITE the fact that no ancient caveman, with his mind over-packed with latent ingenuities, ever dreamed of such an instrument as the violin, nevertheless the craftsmen of centuries dead and gone attained far nobler achievements in this art than the workmen of our modern hour can hope, apparently, to reach. From time to time a tale goes forth of a long-lost cunning rediscovered. Legends abound of secret processes once possessed by makers of fine old violins, and now too elusive for re-capture. So far as he is able, the workman of to-day reproduces faithfully the shape, the size and finish of the instruments of old, in his effort to equal their perfection. He works in the old, time-honored manner. He chisels the top and bottom of the violin's body from solid blocks of spruce and maple, coaxing the subtle and delicate conformations through a month of patient labor, putting his soul and his yearning in the wood, as perhaps no other hand-craftsman may, in his search for an exquisite tone. He is building a slender and sensitive box with a wonderful power to emit vibrations, marshalled into order, and delivered forth as a voice. No visible beauty of carven form and no original departure from the set design avails him in reaching his goal. He seeks the intangible essence of sound and the means for its loftiest beauty. For him there is no established law for alluring the tone to some dimple in the wood, to delight it to rapturous perfection. He pursues an *ignis fatuus* of quivering air-waves that leads him onward endlessly. He may only strive toward achievement of this object as strove his forbears of the craft, and frequently with far less reward.

Perhaps more in this than in any other craft of the hand-art world does the strict adherence to old-time models, methods, polishes, and even glues, obtain. It is all because the past still leads in excellence, and man of to-day, with all his boasted progress, is still far behind in the delicate art of creating those temples, shrines, and homes of the goddesses of sound.

The men we found engaged in this old occupation had been reared in the school of it from boyhood. One in his youth made a tiny violin not half the size of his palm—a perfect thing like a crystallization of his zeal. When, during our visit, he snatched a splendid 'cello from the workroom wall, tightened the strings to consonance, and flung upon them the caressing bow, we knew why it was that all these years he has made these instruments, laboured in the craft, and sought to capture that rarest of elusive things—the perfect and age-rich tone.—Philip Verrill Mighels, in *Harper's Magazine for May*.

Big Tires Wear Longest

THE longevity of tires, a most vital problem with the automobile owner, has recently been put to severe tests by experts in the employ of Thomas B. Jeffery & Co., makers of the Rambler.

These experiments have revealed a remarkable difference in wearing qualities between tires varying only slightly in size.

Many cars, equipped with 36 by 4½-inch tires, were tested against others equipped with tires 2 inches smaller in diameter and ½ inch smaller in width. The larger tires lasted just twice as long. The larger wheels, as well, showed greater power of resistance against strains, being stronger than smaller ones because of their greater weight.

The marked difference between a tire of large size and a smaller tire is accounted for by the fact that smaller wheels drop into holes in the roadway, adding greatly to the wear on tires, as well as to the discomfort of the occupants of the car. Big wheels and tires glide lightly over depressions, providing wider cushioning surface, and thus adding to comfort as well as to tire economy.

Book News

Gas Engines

The Design and Construction of Internal Combustion Engines. A Handbook for Designers and Builders of Gas and Oil Engines. By Hugo Güldner. Translated from the Second Revised Edition, with Additions on American Engines. By H. Diederichs. Size, 8 x 11 inches. pp. xx, 672; with 728 illustrations and 36 folding plates. New York: D. Van Nostrand ompany.

Güldner's treatise on the gas engine has enjoyed an international reputation since the appearance of the first edition in 1902, and hence this revised and greatly-enlarged edition will be welcomed by engineers and designers of power machinery. The interval between the publication of the two editions has marked a period of enormous development of the internal-combustion engine, and this growth is to be seen in the increased size of this volume over that of the first edition.

Part I, of the present volume, covering about fifty pages, deals with the various cycles of operation, including a critical comparison of the four-cycle and the two-cycle engines, this examination showing that while there is theoretically no difference in the efficiency of the two types, there is a practical advantage in favor of the two-cycle engine. In this respect the author takes issue with Professor Riedler, who has maintained that "the gas engine will revert to its original starting point; that is, to the four-cycle principle," and maintains that the "final solution will most likely depend, not upon what *can* be done, but upon what *must* be done."

The second, and most important part of the book, is devoted to the design and construction of internal-combustion engines, and this will be found exceedingly welcome to the practical engineer, containing, as it does, formulas and diagrams for the proportions of the various parts, illustrated and exemplified by dimensioned details of engines by the leading European builders. In this portion the author emphasizes the necessity for less invention and more rational design, believing that ambition of restless inventors should be abandoned in favor of the application of the well-known principles of machine design, as proven by science and tested by practice.

Following the section upon design comes a very full discussion upon construction, erection, and testing, this including illustrated descriptions of the engines of the leading builders of Europe; to which the translator has added similar material relating to American gas engines.

A fourth section discusses fuels and the phenomena of combustion in gas engines, followed by an appendix containing a synopsis of thermodynamics, the principles of thermochemistry, instructions for operation and codes for the conduct of tests. It is to be regretted that the revision of the gas-engine testing code of the American Society of Mechanical Engineers had not been completed in time to permit its inclusion in the present volume, and that the old code had necessarily to be used.

Within the limits of space it has been possible to give but a brief view of the contents of this important contribution to one of the leading departments of engineering work. The combustion engine is doubtless destined to fill a large portion of the field now occupied by the steam engine, and every engineer engaged in the work of gas-engine development should possess and use this book. It contains all the theory necessary for a satisfactory understanding of the principles, and such an abundance of practical material as to render it invaluable to the designer. The translator has done his work well, and is especially to be commended for the conversion of the metric dimensions and constants in the formulas, tables and drawings; while the publisher is also to be congratulated upon the mechanical execution of a difficult piece of work.

Hydraulic Power

Hydro-Electric Practice. A Practical Manual of the Development of Water Power, its Conversion to Electric Energy, and its Distant Transmission. By H. A. E. C. von Schon. Size 7 x 9½ inches, pp. xvi, 382, with 140 illustrations. Philadelphia: J. B. Lippincott Company.

In view of the interest which is at present indicated as regards the conservation of the hydraulic-power opportunities of various countries, especially in the United States, this scientific treatise upon the methods of development of hydraulic power is to be welcomed. There are many treatises upon hydraulics, and though all the problems involved in the flow of water are not yet solved, it is not for lack of much writing about them. The commercial development of a power project, however, involves much more than the mere measurement of water flow and the design and construction of machinery. There are other matters which, when properly considered may make for success, and which, if ignored, are almost certain to involve failure, matters which should be studied by capitalists, financiers, and investors, as well as by engineers, and it is with such a broad and comprehensive view of the subject that we are provided in Mr. von Schon's excellent book.

As he well says, the feature which ranks first in importance is the market for the power to be generated, a purely commercial subject, demanding first attention in the analysis. The market being assured, the power opportunity follows, including the available flow and head, including also questions of a legal and economical nature, as well as financial considerations. After these come the fundamental matters of cost synopsis and its corresponding investment relations, and then, and not until then, are the questions of construction and equipment to be taken up.

This second part of the treatment includes the surveying of the site, including both area, run-off, seasonal variations and structural features upon which a development programme may be blocked out and the mechanical details of dam, motors and transmission determined. Finally comes the question of the actual construction of the plant, a matter which has been so fully provided for by other treatises that the author considers it merely as a sort of conclusion, this in itself showing the original character of the book and its difference from the ordinary treatise on water power.

To the men who are realizing that the future power supply of the world must come from its running water, and who, while not engineers themselves, realize that they must treat the subject fundamentally in the same manner as they would a new railroad project, or a vast manufacturing combination, this book will be most acceptable, while the practicing engineer may learn from its pages, if he has never learned it before, that he must be something broader than a man of applied science, and that he must become familiar with financial and commercial considerations in his work. The modern engineer has been defined as a man who can do for one dollar what any fool can do for two dollars, and he must have some books of this sort if he is to learn the dollar part of his profession.

Astronomy

The Evolution of Worlds. By Percival Lowell. Size 8 inches by 5 inches. pp. xiv., 262. New York: The Macmillan Company.

Again Professor Lowell comes before the public with a work which is certain to attract attention. The present book has already become known, in part, by reason of the fact that, in substance, it consists of lectures which were delivered before the Massachusetts Institute of Technology; but in their collected form they present, as a whole, a view of celestial mechanics which is of much interest to the layman, and which should have especial attraction to the engineer.

Beginning with the question of the birth of a solar system, that resur-

rection which may be caused by the shock of impact of some dead, dark star with another of its kind, Professor Lowell proceeds to show the evidence of such an initial catastrophe to which the birth of our own solar system must have been due, followed by a review of the condition of the planets whose orbits lie within and without that of the earth, and a discussion of the evidence upon which we conclude that our own system did thus have its origin.

In the supplementary notes there are included such mathematical computations as may attract the engineer, but which would weary the general reader, while a copious index concludes a work of deep interest.

The Persistence of Old-Time Methods

In an interesting article upon some of the industrial operations which are still in active use in New York City, Mr. Philip Verrill Mighels describes in Harper's Magazine the work of the tapestry weavers of Manhattan.

The looms we visited are new in the city of Gotham. They are tapestry looms of a pattern unchanged after centuries of use. And the art of the weaver of these fabrics, we are told, is far too ancient for record.

The art we beheld is almost absolutely unaltered. The looms are installed in a studio place that was once a palatial stable. They are copies of what are known to the craft as the Aubusson looms of France. The men engaged in making tapestries upon this old device are foreign craftsmen, trained to their guild and wondrously skilled in the art.

It provided a singular sensation to leave the busy, noisy thoroughfare of modernity and ascend to that conclave of looms so allied to the past. There were two great apartments devoted to this enginery of beauty. Enginery seems the only adequate word. The looms we saw are combinations of huge wooden frameworks, beam-like levers, twining ropes, and tightening devices, the whole resembling those monstrous stone-heaving catapults inseparable from ancient war.

Unlike the tapestry looms at the Gobelin workshops in Paris, these are made to stretch the warp horizontally, about waist-high to a man. At the rear of each loom, on a slanted bench, sit the weavers who work the design. Beneath the warp, and readily visible through its many tight-stretched strands, the pattern lies close under hand. It is drawn on a monster sheet of paper and colored with painstaking skill. Above it bend the weavers of the cloth, each softly supported with pillows. One pillow to sit on and one on which to lean, each workman adjusts to his needs. His colors (the woofs) are wound on spools, and resemble a heap of large-sized, brightly colored and differently hued caterpillars, ready to spin out their substance. There are frequently as many as twenty or thirty of these shuttles beneath one workman's hands.

It is wonderful and utterly bewildering to see these craftsmen weave. Their hands out-machine a machine as they grasp at the warp, to lift two, four, five, or any number of strands, shoot a bobbin in and out, and make a singular tie, to drop that particular caterpillar, clutch up another, tie in its thread, and pounce upon a third or fourth, and return, perhaps, to number one. They keep those red, green, gold and purple caterpillars in a constant state of agitation. They grasp at the warp and play in a strand and finger new strings, as if the cords were the wires of some silent harp on which they play a ceaseless composition that expresses itself in color. Yet fast as their fingers seem to play upon this soundless instrument, it is slow, hard toil with eyes and hands to stitch in those units of the scheme.

THE LATEST CATALOGUES

In writing for Catalogues, please mention Cassier's Magazine

Machine Tools

The Billings & Spencer Company, Hartford, Conn. Handsomely printed and profusely illustrated catalogue of the machinists' tools manufactured by this firm, including those well-known "B. & S." specialties, such as adjustable wrenches, adjustable automobile wrenches and "S" wrenches, adjustable pocket wrenches, adjustable pipe wrenches, spanner wrenches, all-steel screwdrivers, magazine screwdrivers, hammers, ratchet drills, lathe dogs, planer tool holders, cutting-off tools, etc. The catalogue contains much very valuable information presented in an attractive manner.

Drop Hammers

The Billings & Spencer Company, Hartford, Conn. Convenient and attractive catalogue for 1910, handsomely illustrated and printed, has just been issued. Contains full description and many illustrations of the drop hammers, trimming presses, trimming millers, hot saws, heating furnaces, annealing furnaces, etc., manufactured by this well-known firm. The long list of representative firms using the Billings & Spencer Drop Hammers clearly indicate the high esteem in which they are regarded.

Accumulators

Electric Storage Battery Company, Philadelphia, Pa. Bulletin No. 121 is devoted to an illustrated description of the newly-installed Chloride-Accumulator cells two series of which have been connected into a storage battery. This has been established in order to mininmize the fluctuations of the load on the generating station, and this unique equipment has shown many advantages not anticipated when the plant was designed.

Rock Crushers

Jeffrey Manufacturing Company, Columbus, Ohio. Bulletin No. 39 published by this company describes the Jeffrey standard roll coal crusher, the extra-heavy triple-geared coal crusher, the standard roll coke crusher, the Jeffrey salt crusher and Jeffrey disintegrators and pulverizers. All these apparatus are clearly and well illustrated.

Injectors

Ohio Injector Company, Wadsworth, Ohio. In the new catalogue No. 27 are found descriptions and illustrations as well as prices of the following machinery: locomotive, automatic and double-jet injectors, ejectors, fire jets, sight-feed lubricators, oilers and several types of valves.

Arc Lamps

General Electric Company, Schenectady, N. Y. In Bulletin No. 4717 the flame arc lamps made by the above-named concern are described in detail and profusely illustrated. The lamps taken up comprise various types of direct and alternating-current apparatus, all parts of which are illustrated. Data regarding all properties of these lamps are also contained in this publication.

Gas Flow Meters

General Electric Company, Schenectady, N. Y. Recording and indicating meters measuring the flow of air or steam in pressure pipes are given a thoroughly detailed description in the company's Bulletin No. 4720, in which the construction and operation of, as well as methods of making observations with these instruments are treated. A number of tables complete the information assembled in this booklet.

Cement

Alpha Portland Cement Company, Easton, Pa. A remarkably handsome illustrated publication explaining in popular language the applications and uses of Portland cement and the wide-spread use of Alpha Portland cement by architects, engineers and contractors. Data concerning the methods of making concrete, of comparative costs of brickwork and concrete, and of the methods of utilizing concrete for a great variety of constructions are given.

A convenient table of definitions of cement terms, in popular language, and a classified list of use for Portland cement, add to the value of the pamphlet; illustrations of buildings, bridges, retaining walls, and similar works in concrete are included.

Tube Cleaners

The General Specialty Company, Buffalo, N. Y. A pamphlet entitled "Pictorial Proof," filled with illustrations of the results with the "Demon" and "Torpedo" cleaners for removing scale from boiler tubes. The construction of the tools is clearly shown, and photographs of the quantities of scale removed indicate the effectiveness with which they work. Diagrams showing the loss due to scale in boilers and of the power required for operating various cleaners furnish useful information.

Steel Lath

Trussed-Concrete Steel Company, Detroit, Mich. Pamphlet setting forth the use of Hy-rib, a form of steel lath, stiffened by rigid high ribs, and adapted for the construction of floors, roofs, walls, partitions, ceilings and furrings. This material is adapted for use with beams of reinforced concrete, steel, or wood, and possesses marked advantages in all kinds of construction.

Expanded Metal

Northwestern Expanded Metal Company, Chicago, Ill. This company has just issued a booklet containing various designing data for the use of expanded metal and expanded metal lath which will be valuable and interesting to builders and mechanical engineers.

Aeronautic Motors

The Adams Company, Dubuque, Iowa. The handsomely finished catalogue of this firm is devoted to the description of the Adams-Farwell revolving motor, consisting of five cylinders arranged around a common crank in a horizontal plane. The motor revolves without vibration and acts as a gyroscope aiding to keep the flying machine in the horizontal position.

Furnaces

W. S. Rockwell Company, New York. Catalogue No. 8 just published by this firm describes and illustrates oil and gas-fired furnaces for forging, flanging, plate heating, angle-bending, spring-fitting, case-hardening, tempering, annealing, etc.

Rotary Engines

Harriman Engine Company, Boston, Mass. Book C of this firm treats of the rotary steam and gas engines, compressors and pumps, which were developed from the inventions of Mr. J. E. Harriman, Jr. The working operation of these machines is described and their advantages explained.

Electric Motors

Fort Wayne Electric Works, Fort Wayne, Ind. Bulletin 1119 takes up the description of the Northern "B" type D. C. motors built by this firm. The motor and its coupling to various machines are illustrated.

Hauling Power

A NUMBER of years ago, when the practical possibilities of long-distance power transmission over a wire by means of electricity were under development, the question of the most efficient method for the transmission of power over considerable distances came up for discussion before one of the professional engineering societies. Electricity, compressed air, hydraulic pressure and other methods all had their advocates; but the fact was finally developed that by far the most efficient method for delivering large amounts of power over great distances was to be found in the simple plan of hauling coal over a railroad track.

Assuming that coal represents the most concentrated form of stored energy with which we are familiar, at least so far as commercial utilization is concerned, and taking into account the well-determined cost of railway transport as the other element in the problem, it might be easy to compare this apparently crude method of long-distance power transmission with others in use and reduce the statement to precise figures.

However this may be, there is no doubt that for a long time to come the use of the railway and the coal car will continue to be the principal means for conveying power in the stored form of coal, and that electric transmission and its allies will find their principal application in connection with hydraulic power stations, in which the passing energy must be seized and delivered as it flows.

Just as the long-distance electric transmission line, when it enters the terminus, delivers the high-voltage current to transformers and switches for distribution to local users, so the long coal train, or deeply-laden collier delivers its burden of bottled-up power to the storage yard or wharf, from which it must be taken to the bins or yards for subsequent distribution. In this local handling the specialized form of coal railway and car comes into active service, and, when properly designed and installed, forms as efficient a method in its way as the main line railroad does for the transit from the mine to the metropolis.

It might be assumed that the local railway, whether operated by steam, electricity or cable, would be less permanent or durable than the wire over which an electric current is carried, but experience has demonstrated that the machinery of transit is more enduring than the power by which it is driven. Thus, a local cable railway, installed for the purpose of taking coal from the wharf to storage, a distance of 800 feet, and handling more than 150,000 tons of coal a year, has been in operation for more than fourteen years, having outlived two motor houses and one entire timber trestle, besides the wharf at which the coal was delivered. This corresponds to more than two million tons carried 800 feet, or, say, 300,000 miles of service. Since the plant from which these figures were obtained is still in service and gives every evidence of continued long life, it is apparent that the endurance of such a system compares most favourably with that of any other method of power transmission, and confirms the view that one of the most effective methods of delivering power is to haul it on a railway in the form of coal.

While the transport of power in the form of coal is thus capable of comparison with the transmission of power in the shape of electric energy, it must be remembered that there are other materials besides coal which demand transportation, and for which the electric wire is not available. These, too, can be carried to the same advantage as coal by similar methods, and thus the railway has the advantage of flexibility as to material as well as efficiency in operation.

Efficiency in Rope-Driving

WHEN it is necessary to transmit power from one rotating shaft to another shaft parallel to the first, and within a reasonable distance, there is probably no simpler method than to use a flat belt of leather or rubber. In practice, however, shafts are often in other positions than in parallelism; they are frequently too close or too widely separated to enable a belt to be used to advantage, and they are frequently so situated that a belt cannot be employed at all.

When ropes were first used in place of belting they were employed for the same direct service that had been fulfilled by the belt, the number of ropes being made proportional to the amount of power to be transmitted, and each rope being separate and independent of every other. This method had the same limitations as the ordinary flat leather belt, but possessed certain advantages over belting, especially for the transmission of large powers. When the American system of rope drive was introduced, however, using a single rope wound a number of times over the driving pulleys and over tension and winding idlers, the scope of rope driving became immensely extended, and it was found possible to deliver power between shafts very close together, very widely separated, situated at any relative angle, with either direct or reverse motion.

When to these possibilities were added such important features as lower first cost, less maintenance expense, freedom from noise, absence of slip and large overload capacity, it was found that rope driving had many applications, and it naturally came into most extensive use.

A well-designed rope drive looked so nice and ran so smoothly that very often an inexperienced engineer thought that he could install just the thing he needed without consulting any expert engineer. The result of such attempts was very frequently either failure or inefficiency, and such experiences served to discredit a system which, had it been properly installed, would have given full satisfaction and high efficiency.

A rope drive should be designed in each instance and be adapted in every case to the actual conditions obtaining as regards location, capacity, speeds and nature of service. A design which is giving perfect satisfaction and high efficiency cannot be copied blindly for use in another place with assurance that it will give good service, since the operative conditions may vary to such an extent as to require entirely different treatment. Such copying resembles the practice of taking medicine for one ill which had been prescribed for some ailment of an entirely different nature, and the results in the two cases have about the same chance of success.

The importance of individual design in rope driving for the attainment of high efficiency is demonstrated by the fact that the principal installations which have produced remarkable results are those to the design of which was brought the widest experience and the greatest degree of skill. The works manager is sometimes self-deceived in this matter by the fact that the narrow limitations of belt driving have rendered it possible for him to become familiar with the best available methods for the belt system of power transmission, and hence he feels equally competent to solve any installation for rope driving. As a matter of fact, the best engineering skill should be given to either belt or rope driving, and it is only by such attention that maximum efficiency can surely be attained; but the remarkable flexibility of the American system of rope driving renders it practically impossible for anyone who is not closely familiar with its possibilities to insure the attainment of that efficiency which the experienced engineer can readily secure.

Flexibility in Shop Operations

ONE of the remarkable differences between the old-time machine shop and the modern works appears in the extent to which the work is performed along the lines of least resistance. Formerly the heavy tools were placed where it was most convenient to stand them, regardless of the difficulties and delays which might be produced in their operation. Very often the controlling consideration was the delivery of the power, and the position of the shafting and the location of driving pulleys being the first things to be considered, were allowed far more weight than subsequent convenience in operation.

In the modern shop it is the results which count. The routing of the work controls the placing of the tools, and the handling machinery is installed to facilitate every movement of the work in its continuous progress from the crude to the finished state. Tools are made portable whenever practicable, if heavy work is to be operated upon, following out the principle that the smaller should be taken to the larger. Thus, the older riveting machine was large, heavy and stationary. A big girder or a large boiler-shell had to be slung, manipulated and moved accurately to position, necessitating slow operations, and forbidding any attempt at rapidity. To-day the portable riveter does the work, and the heavy piece, once brought to the proper place in the shop, remains stationary until the work on it is completed. To suspend and control the heavy piece of work itself demanded a powerful crane of deep reach, and the fact that "large bodies move slowly" was continually demonstrated. The portable riveter, however, may readily be suspended from a Triplex block attached to an overhead trolley, and the whole brought promptly and precisely to the point of operation, all the activity being transferred to the smaller and lighter mechanism. This is but one illustration of the modern method, but it serves to show how the tendency toward facility and flexibility in machine-shop operations is increasing the productive capacity of the establishment. Fewer men with greater output is the aim, and this with less effort on the part of the men who remain. The old-time labouring gang is rapidly disappearing, or is greatly reduced in numbers, and the heavy work is either performed by machinery, or, by skillful re-arrangement of methods, is avoided, so that lighter, more convenient and more efficient devices may be employed. It is all a part of the industrial evolution which is continually going on about us, and it makes for better work, more easily performed, at less cost.

All this development in flexibility in shop operations is the result of the united efforts of many men and many manufacturers, extending over a period of years, and bearing its fruition gradually as the time has passed on. The chain block, as originally produced in the form of the differential hoist, and passing through the stages of the duplex and Triplex block, was originally devised merely for the purpose of lifting loads and replacing with greater convenience and efficiency the old-time rope tackle. Having accomplished the purpose for which it was primarily devised, its use has been extended into the wider field of general shop service as an attendant upon various machine tools to hold and guide the work, and to bring the tool itself to the point of application, thus aiding in the transformation to which reference has already been made.

Such appliances as the triplex block have been called "labor-saving" devices, doubtless because they have reduced the amount of mere physical effort demanded in performing certain operations. As a matter of fact, such inventions increase the amount of work actually done because they enable much more to be accomplished with the same effort.

A Triplex Block for Quick and Accurate Adjustment

IN rivetting a box girder, take the girder to a rivetter on a Triplex Block. Thus the rivetter may be instantly brought into position and guided to the right spot with unfailing accuracy.

And for speed and accuracy nothing answers the purpose as well as a Triplex Block suspended from a trolley, as shown in the accompanying illustration. Possessing in itself the simplest, strongest and easiest running hoisting mechanism ever built, it can be operated by one man.

For simplicity, economy, durability and security, it is the handiest one-man mechanism found in any structural shop to-day.

CHAIN BLOCKS

4 styles: Differential, Duplex, Triplex, Electric
42 sizes: One-eighth of a ton to forty tons.
300 active stocks: ready for instant call all over the United States.

The Book of Hoists tells much—for a Post Card.

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Only Makers of Genuine *Yale Products*

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Canadian Warehouses: The Canadian Fairbanks Co., Ltd., Montreal, Toronto, St. John, N. B., Winnipeg, Calgary, Vancouver.

Mechanical Invention, Discovery and Exploration

MECHANICAL or industrial inventions, such, for instance, as are usually the subject of letters patent, seem to be of two quite distinct types — so essentially unlike, in fact, that they may, perhaps, be better differentiated and distinguished by using different words in speaking of them. To the one, and the most numerous, class, the word "invention" intelligibly applies, while those of the other class may be designated as discoveries.

In the one case the inventor sets out to accomplish some definite result, usually by mechanical agencies, and for this he selects combinations of operative devices, mostly familiar in detail, but which accomplish the new result desired. Of this class of true inventions are the typewriter and the sewing machine, and, in a larger way, the locomotive.

The inventions of the other class, the discoveries or "happy thoughts," are recognizable by all as essentially different from these. They come to the few; they come in their entirety at once; they come unheralded; but they do come to those who are alertly and intelligently seeking such things rather than to those who are not so on the lookout. Sometimes the discovery is that of an important detail of a more or less familiar but constantly improvable machine, as, for instance, the piston inlet of the air compressor. Such a discovery as that bars all imitation; you either have it or you have it not, and, when priority of discovery is established, it completely protects itself against all infringement.

In the discovery class we must place also the electric air drill. It combines a single happy thought which is the central and dominating idea of the apparatus as a whole.

The discovery analogy extends beyond the first incident of perception, recognition and appropriation. After the discovery becomes an accomplished fact the thing discovered must still be investigated and, as we might say, explored, that all its bearings and relations may be known and all its accompanying advantages made available, just as an island or a continent newly discovered must be explored and mapped. To the explorer surprises come, and it often happens that he finds the world more enriched by the new discovery than was at first realized. Analogous to this are the revelations which experience brings concerning the electric air drill.

When the idea of it was first entertained it was evident at once that here was provided at least the possibility of dispensing with air-compressor plants and long lines of piping in mining and other rock-cutting operations. In the adoption of revolutionary improvements it is seldom that it is all clear gain. There are usually sacrifices or compromises to be made, and before the final adoption of the electric air drill these were to be looked for. They have not been found. The drill in working is not in any respect inferior to the drill driven by constant air pressure. The drill itself is much simplified, the most troublesome and costly details, both in construction and maintenance, having been eliminated. The drill actually strikes a harder blow, because the air from one pulsator follows the piston with an increasing pressure, while the other pulsator makes a decreasing pressure on the other side of the piston. The drill practically forgets its old habit of sticking in the holes, because the pulsators keep the air yanking at it, one side and then the other, so that if it does stick for a moment it is free again before anything can be done about it. The most surprising thing of all is that the electric air drill requires much less than one-half the power, at the source of power, which the direct air-operated drill requires to do the same work.

Fireproof Construction

ONE of the features of reinforced concrete construction for factories and manufacturing buildings of all sorts appears in the effectiveness with which fireproof construction is attained by such systems.

The materials of which concrete is composed — cement, broken stone, sand or cinder—have already been through the fire, and can be no further harmed by it, and their combination with proper metal reinforcement gives a structure which includes both the compressive strength and the fire resistance of the concrete and the tensile resistance of the metal, the latter being imbedded deeply enough to insure its protection against any deformation by heat.

Concrete walls and foundations are well enough known, but it is also well known that these alone are not sufficient to insure protection against fire. Partition walls, floors, roofing—all these may furnish food for flames if they are made of inflammable materials, and hence it is necessary to resort to monolithic construction, with all its attendant expense, unless some other method becomes possible.

It is only natural that this element in reinforced concrete construction should be considered by engineers who have devoted themselves to this department of work. Various forms of metallic lath have been produced, these requiring studding, to which they are attached, or metallic construction of some sort to form the resistance of the surface against deflection stresses. One of the most effective of such devices, however, is so devised as to include within itself the necessary stiffening, being made with deep ribs, which, in themselves, offer resistance against deflection, and render unnecessary any purlins, studding, or similar auxiliaries.

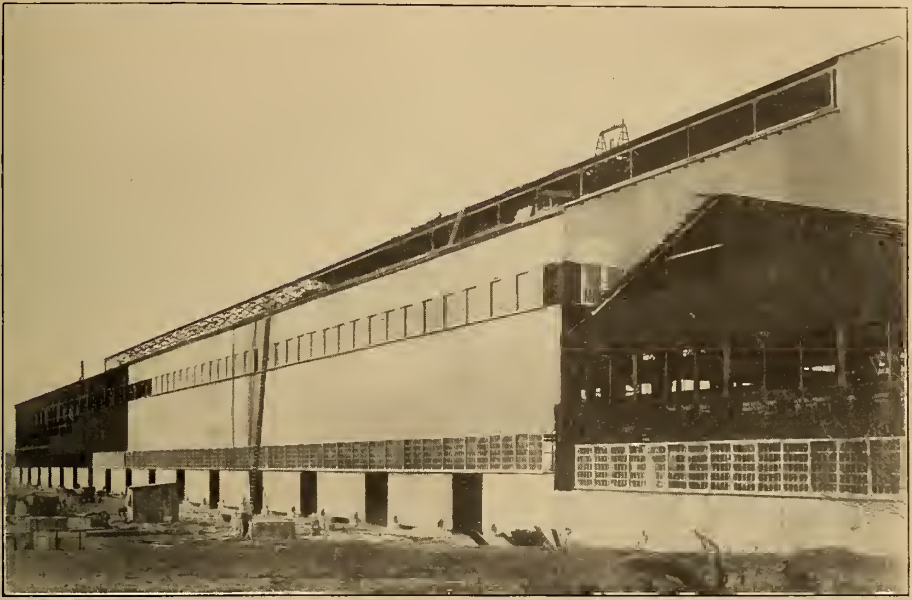
Such a material can be used for form siding or partitions simply by setting it up in position and applying the plaster to both sides, this forming a thin concrete slab of great rigidity, which is proof against fire and decay. Since the effect of the studding is included in the stiffening ribs of the lath, no studs such as are required for ordinary lath are needed.

When used for roof construction the ribbed lath is laid over the steel purlins, the concrete being poured in from above and the under side plastered. It is evident that this method does away with the necessity for any centering or falsework, and thus one of the principal items of expense in concrete-slab work is avoided. The advantages of the method are evident, and the system has been employed in hundreds of buildings throughout the United States.

It is apparent that this system for the construction of floors and partitions is not limited to factory buildings, and it has been successfully employed on buildings designed for offices, stores, hotels and similar purposes. It is also applicable for furring walls and for the construction of arched floors.

The care which is being taken to extend the use of reinforced concrete construction to all details of the work is apparent in the design of this so-called Hy-rib material, including, as it does, the flat lath surface and the raised rib to give it the necessary stiffness. Properly designed beams and reinforced walls enable the main structure to be erected in a wholly fireproof manner, while this type of stiffened lath adds to the walls and beams the necessary reinforcement which permits partitions and floors to be made in a manner equally safe and resistant.

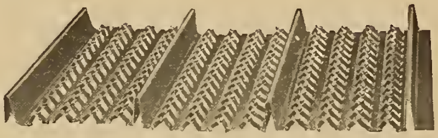
In the early days of reinforced concrete construction many designs were made which were both unsatisfactory and inefficient; the application of sound engineering principles and of inventive talent has made it practicable to secure all the advantages of concrete, reinforced with steel, in a manner at once economical and efficient.



HY-RIB ROOFS AND SIDING

To make your factory or warehouse permanent and fireproof at very little cost, use HY-RIB plastered with cement for roofs and siding. Saves insurance, repairs and painting. Much more economical than short-lived, leaky corrugated iron or quick-burning wood sheathing.

Used in hundreds of buildings for Roofs, Siding, Floors, Ceilings, Firring, etc.



Hy-Rib is a steel sheathing stiffened by deep ribs made from the same sheet of steel. **Does away with centering in floors and roofs, and with studs in walls and partitions.**

Merely set the Hy-Rib sheets in place, apply the cement mortar, and the slab is complete. So simple that your own men or local builders can erect it.

Before you build, write us for complete information and **free Hy-Rib Catalog.**

Hy-Rib is one of the products of the Kahn System of Reinforced Concrete —used in over 4,000 important buildings.

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546 Trussed Concrete Building, Detroit, Mich

Quality in Transmission Machinery

IN the old millwright days, when shafting, pulleys, hangers and all the details of power-transmitting machinery were made in a rather rough-and-ready manner, they were not considered as machinery at all, but rather as a sort of builders' work; and, so long as they did the work, small attention was paid to their crude appearance, excessive weight and low efficiency.

At the present time, however, there is probably no portion of machine design to which more care is given than that including transmission elements. Engineers have begun to realize that a considerable portion of the power which is produced in the engine room or turbine house is absorbed in delivering it to the point where it is used, and they have also found out that true shafting, balanced pulleys, continuously lubricated bearings and firm hangers and pillow blocks all make for the reduction of power wastes and the attainment of high efficiencies.

The superintendent or engineer who is purchasing a lathe, milling machine or planer makes a most careful inspection of the design and execution of the tool before he decides upon its purchase and installation in the shop, and yet in many, very many, instances such a tool, even under its heaviest duty, consumes less energy than the power-transmitting elements by which it is served. That these facts are realized by the modern operative engineer and manufacturer is evident by the extent to which a high degree of perfection is demanded in manufacturing establishments of the better class. It is not enough that shafting shall be fairly round and reasonably straight; it must be true, stiff and highly finished. Pulleys, especially of wide face, should have not only a standing balance, but run truly in balance at the speeds required for modern cutting tools; hangers should be of graceful design, and be rigid without excessive weight; bearings should be properly proportioned and continuously lubricated, without wasting oil; and, in general, all the fundamental principles of machine design should be observed with the same juricious care as with a machine tool of the highest class.

In connection with the subject of transmission machinery it is interesting to note the increasing use of the clutch for connecting and disconnecting members in starting and stopping. Formerly a clutch was used only when absolutely necessary, dependence being placed upon shifting belts and similar contrivances. The introduction of rope driving with grooved sheaves and multiple turns rendered fast-and-loose pulleys impracticable, and hence some effective and reliable form of clutch became necessary. With the development of satisfactory clutches for large powers it was thus found possible to do away with the troublesome loose pulley, and to-day the high-class clutch forms an essential element in a well-designed transmission system. The extent to which the clutch is used in connection with the automobile is ample evidence of the popularity of this method of control, permitting, as it does, the gradual engagement or prompt release of connection with a continuously running motor.

The present time is marked for the efforts which are being made on all sides for the reduction of wastes, and the whole question of profit or loss sometimes depends upon the utilization of waste products. In many manufacturing establishments the waste of power forms a very important item in useless expenditure.

The wise manager, in his efforts to stop all leaks, does well to investigate the extent to which power losses in transmission may be minimized, and thus is brought to realize the monetary value of high quality in all departments of the transmission system of his establishment.

Manufacturing News

The Transmission System of the Idaho-Oregon Power Company

THE present transmission system of the Idaho-Oregon Light & Power Co. in the region surrounding Boise, Idaho, comprises two water power generating stations, one of 1,500 kilowatts capacity at the Horsehoe Bend of the Fayette River and one of 900 kilowatts capacity at Barber Dam on the Boise River, six miles from the city of Boise, together with about 112 miles of high tension transmission line, approximately one-half of which operates at the transmission potential of 66,000 volts and one-half at 23,000 volts.

The two generating stations, above referred to, at the present time supply the principal load of the system, the lighting and traction service of the city of Boise, through 23,000 volt lines. To supply the region north and west of Boise, where, besides the local service, power is used for mining, a transformer sub-station has been installed at Emmett, 42 miles from the city and 16 miles beyond the power plant on the Horseshoe Bend line, stepping up from 23,000 to 66,000 volts through three 1,000 kilowatt delta-connected Westinghouse transformers. From this station the 66,000 volt lines continue through the Plymouth and Ontario sub-stations to the Weiser sub-station. Sixty-five miles northwest of this point the Idaho-Oregon Company is building the great Oxbow hydraulic water-power plant on the Snake river, which will make available approximately 30,000 horsepower, and will ultimately be used to supply the principal load of the system at Boise at a transmission distance of 125 miles.

When the Oxbow station is completed and put into operation, the Horseshoe Bend and the Barber Dam plants will be operated as auxiliary generating stations.

One of the interesting developments of the Idaho-Oregon installation has been the performance, as recorded in service, of the Westinghouse type "GA" oil circuit breakers. On this transmission system there are now four of these three-pole units operating. Two of these are in the Emmett sub-station and one in each of the Weiser and Ontario sub-stations.

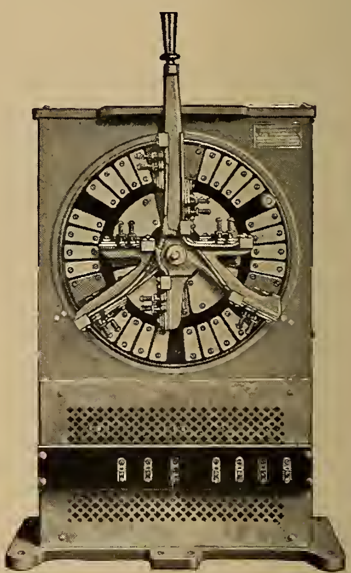
The Westinghouse type "GA" circuit breaker is made up of single pole units immersed in oil in separate boiler steel tanks, without other connections than the operating or pull rods working the contacts. The operating system consists of a single arrangement of levers, bell cranks and links, actuated by a toggle from the switchboard handle. The trip

coils are actuated from the low tension winding of series transformers connected in the line wires. In the newer and present standard type of these circuit breakers above 100 amperes capacity, these series transformers are mounted directly over the high tension bushings of the breaker forming a part of the breaker.

The 66,000-volt "GA" circuit breakers for the Idaho-Oregon system have a total break of about 17½ inches per contact, or 35 inches per pole. Each breaker has a rated capacity of 300 amperes, being especially designed to open the circuit under severe conditions. The small space and head room required by this apparatus especially recommends it for installations where space is limited, and the thorough insulation afforded by its oil immersed contacts in lined tanks, the internal insulating barriers and condenser terminals insure the reliability and safety of its operation in handling the heaviest overloads and short circuits. The ease with which these circuit breakers are installed and adjusted and the accessibility of all operating parts for examination are also important items in gaining the favor of operating men where "GA" breakers have already been put into service.

The "GA" circuit breakers on the lines of the Idaho-Oregon Light & Power Company have already been operated more than six months, and during this time have handled some extreme overloads and surges in a manner gratifying to the company's engineers. Several surges have occurred in which the voltage rose beyond the scale of the meters, 90,000 volts. These phenomena have been observed during heavy wind storms and when the Boise sub-station trips out. The Boise load is inductive and tends to neutralize the heavy capacity of the lightly loaded transmission line. No static appears on these terminals, although at times the wiring and porcelain insulators have displayed considerable corona. The performance of these circuit breakers has been a source of much satisfaction to the operating officials, as their operation has been uneventful and dependable under all conditions so far met during the most severe season of the year.

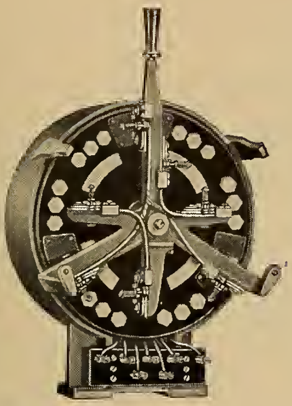
The complete electrical equipment of the power generating and transmission system, including alternators, sub-station apparatus, transformers, switchboards and circuit breakers, was furnished by the Westinghouse Electric & Manufacturing Company, Pittsburg, Pa.



ALTERNATING-CURRENT CONTROLLER.
Electric Controller & Manufacturing Company, Cleveland, Ohio.

A New Line of Alternating-Current Controllers

UNTIL quite recently, direct motors were used almost exclusively for operating electrically-driven cranes and mill machinery. However, the flexibility and ease with which alternating-current may be transmitted have within the past few years resulted in a large and increasing use of alternating-current motors for these applications.



ALTERNATING-CURRENT CONTROLLER.
Electric Controller & Manufacturing Company, Cleveland, Ohio.

For this character of work the series-wound direct current motor has the very desirable characteristic of high starting torque. In alternating-current motors this feature is more nearly found in the slip ring type of motor than in the squirrel cage type. Therefore for the operation of cranes, mill tables and other reversing work of a similar nature, the development of the alternating-current motor has leaned heavily towards the use of the slip ring motor. Speed and torque control are obtained by inserting and varying resistance in the secondary winding of the motor.

The Electric Controller & Manufacturing Company, of Cleveland, Ohio, has developed a comprehensive line of manually operated controllers for slip ring alternating-current motors from one to one hundred horsepower. These controllers follow as closely as possible in design and construction the direct-current controllers which this company has been manufacturing for years. In fact, wearing parts on alternating-current and direct-current controllers are interchangeable to a large extent.

The controllers illustrated are for use in connection with reversing slip ring motors, either two-phase or three-phase. The resistance is entirely self-contained, it being necessary to connect only seven leads to the controller. Where heavy currents are to be handled, cast grid resistance is employed and unusual precautions have been taken to insure insulation which will be permanently satisfactory.

The operation of all of these controllers is by a lever motion which the manufacturers consider advantageous for crane and mill service. Although the cuts illustrate controllers for slip ring motors only, yet the Electric Controller & Manufacturing Company has furnished and is prepared to supply controllers for squirrel cage motors and alternating-current commutating motors.

With the Railroads of Three Countries

THREE railroad articles of widely diverse character are found in the June number of *The World's Work*. In addition there is an excellent full-page portrait of Mr. W. S. Stone, secretary of the Brotherhood of Locomotive Engineers. "The Shifting Railroad Control" is the title of a valuable article by C. M. Keys, which reviews the sweeping changes in our railroad ownership and control since the death of Mr. Harriman. The present condition may be seen at a glance from Mr. Keys' maps of each system as it exists to-day.

In the mass of railroad stories, truth and fiction, it would be difficult to find anything as interesting as Charles Frederick Carter's reminiscences in connection with the "Big Hill" of the Canadian Pacific. This dreaded four-mile stretch, with its 237 feet to the mile incline and 11.5° curves, has finally been eliminated by two spiral tunnels and the expenditure of $1,270,000.

Half-way around the world from the scene of the other two articles and differing widely from either of these is a profusely illustrated article on "Manchuria's Strategic Railroad," by a Japanese, Mr. T. Iyenaga, a professional lecturer of the University of Chicago.

FAY & EGAN NEW HAND BENCH PLANER.

A New Bench Hand Planer

REALIZING the many practical advantages of having a small hand planer in the wood shop, the J. A. Fay & Egan Company, have designed a machine, called their No. 254 Bench Hand Planer. This machine will do a great variety of small work. It occupies very little space and accomplishes the work more rapidly and conveniently than a large machine. The construction of the machine is as complete in every respect as the large type of machine. Tables six inches by 20 inches long are adjustable on long gibbed inclines free from vibration, and the fence is arranged to angle to 45 degrees. Cutter head bearings are of improved self-oiling type. The manufacturer's safety circular cutter head is used on this machine. With each machine the manufacturers furnish at slight extra charge, when ordered, a bench box on which to set the machine. The box has a hole in the top to receive the shavings and is supplied with doors for removing the shavings.

The manufacturers have just issued a descriptive circular of this machine which they will be glad to send you by return mail. Address the manufacturers at 226-246 W. Front St., Cincinnati, Ohio.

Standardization in Automobile Work

IN an address recently delivered by Mr. Howard E. Coffin, president of the Society of Automobile Engineers, the subject of the opportunities for standardization of automobile work is emphasized, and the following extracts will show the extent to which such standardization may well be effected without hampering the individuality of the designer and builder.

It is superfluous to say anything as to the great need for concerted action on the part of our motor car engineers. Every purchasing department in the business is being seriously hampered in its work by the utter lack of uniformity in the material specifications, which are being passed on to them by our engineering departments. Every individual engineering department is a law unto itself in nearly all matters touching design and the preparation of specifications. Individuality of design is one thing and should be encouraged. Individuality in specifications is largely useless and should be restricted within reasonable limits. As a case in point, the engineering department of one concern has lately delivered to its purchasing department material specifications upon which six months' delivery dates are

the best promised. As a direct excuse for this delay the mills report their utter inability to care properly for the multitudinous and special demands which are being made upon them by motor car engineers. Among the similar situations which confronted the mechanical branch some three years ago was the question of steel tubing sizes and deliveries. The tube mills reported to the investigating committee not less than 1,600 different sizes of tubing which they were being asked to supply for the motor car trade. Few, if any, standard sizes could be stocked, because of the minute and immaterial differences in the specification in each individual case. The committee having this work in hand unearthed the further astonishing information that the specifications being turned in to the tube mills by individual automobile makers building only one or two models covered not less than eighty distinct sizes or thickness of wall.

With purchase orders in hand covering 1,600 different specifications through the comparatively limited range of the tubing diameters used in motor car work, it is small wonder that the expression of the tube mills' management to our committee was "for God's sake, do something." The net result of the mechanical branch work in connection with the tube mills will be found in a printed and framed table supplied to every engineering department within the association. In this table were listed something like 150 sizes of tubing actually needed in automobile work, and upon which practically immediate delivery was guaranteed by the mills.

This tubing list again needs attention. The sheet metal situation is little better than was that upon tubing three years ago. There are a dozen other examples which might be cited wherein standardization work would in no way affect individuality of design, but would very greatly lessen the purchasing department problem.

We see much in the press and in the advertising columns about the standardization of the modern motor car. There may be something in this term, if by it we mean that every car has a motor, a clutch, a transmission, a frame, springs and axles, but it is not any of these big generalities which cause the trouble or which need standardizing. It is the little things—the little things which are different merely because they are different and for no good reason—which keep the purchasing departments in hot water and delay production. Nine times out of ten it is not the unavoidable act of Providence which delays the output—it is the irresponsible draftsman or designer who is permitted to draw upon his imagination for specifications throughout the entire range of theoretical possibilities.

Exhaust Steam Turbines

Taking advantage of the opportunity offered by the low pressure steam turbine when used in connection with the exhaust of other prime movers, for increasing plant output without requiring additional boiler capacity, the Baldwin Locomotive Company is installing three 500 kilowatt low-pressure units at its Philadelphia works. These turbines will utilize the exhaust steam from Westinghouse compound reciprocating engines already installed in the large power plant of these shops, making available a considerable additional amount of power and effecting marked economical improvement in operation of this station.

The turbines practically make a third stage in the expansion of the steam from the compound engines—a step forward in the economical use of the steam.

The increasing shop demands on the power house, following the return of the business tide, required this additional power equipment, and in making extensions along these lines, sacrifice of the existing steam generating apparatus, which is in good condition, has been avoided.

News Items

The catalogue of the new Rambler, just issued by Thomas B. Jeffrey & Co., contains, among other striking illustrations, a beautiful color frontispiece of the new Rambler Fifty-five, the leader of the Rambler line for 1910. The new Rambler is built in one of the largest automobile factories in the world. Every part of the car is made in this plant, which has been in operation every single working day for nearly ten years. The new Ramblers are said to be superior in point of quality to all previous Ramblers, and now rank among the highest-priced cars, although the new 45 horse-power Rambler sells for $2,500.

The Raymond Concrete Pile Company, of New York and Chicago, has been awarded the contract for the concrete piles and foundation of the marine barracks at the League Island Navy Yard, Philadelphia. Rankin, Kellogg & Crane, architects; P. J. Hurley, general contractor.

The Proceedings of the Nineteenth Annual Convention of the American Railway Bridge and Building Association, held at Jacksonville, Fla., October, 1909, have been published. The book contains committee reports on electric transmission lines, bridge inspection, water and coal supply, turntables, derricks and push cars, pile and frame trestle bridges, material yards, docks, wharves, etc.

Frederick Maynard Mann, for the past eight years professor of architecture at Washington University, has been appointed professor of architecture in charge of the department at the University of Illinois.

Professor Mann prepared for college at the Minneapolis High School and graduated from the university of Minnesota, receiving the degree of Bachelor of Civil Engineering in 1892. After graduating he entered the Massachusetts Institute of Technology, receiving the degree of Bachelor of Science in Architecture in 1894 and Master of Science in Architecture in 1895. He received the degree of Civil Engineer from the University of Minnesota in 1898. He traveled abroad for the study of architecture during the summers of 1896 and 1897.

After leaving the institute Professor Mann was for several years in professional practice with Peabody and Stearns of Boston, with Cope and Stewardson of Philadelphia and later in independent practice for himself in the latter city. Among the structures of his design may be mentioned the Class of 1873 Memorial Gateway at the University of Pennsylvania, the Memorial Church of St. Paul and the parish house for the same, the Church of St. John the Evangelist and the "Maryland" bachelor apartments, all in Philadelphia or vicinity. His list of buildings also includes a number of important residences. Professor Mann has also developed a general plan for the grounds and buildings for the University of Texas and has designed some of the buildings of that institution. He acted as professional adviser to the St. Louis Library Board in connection with the city's new central library building, in formulating a programme upon the basis of which Mr. Cass Gilbert was appointed the architect. Professor Mann was instructor in architecture at the University of Pennsylvania from 1895 to 1900. Since 1902 he has been Professor of Architecture at Washington University, where he has had an opportunity to originate and to develop a department which has attracted the favorable attention of architects all over the country.

As the result of an experience covering nearly half a century, the Joseph Dixon Crucible Company announces that a combination of silica-graphite pigment and pure linseed oil (the Dixon formula) will give a surface protection excelled by no other paint.

MANUFACTURING NEWS

The Speed of Riveting by Machinery

THE following interesting information as to the speed at which rivets can be driven by a compression riveter is furnished by the Chester B. Albree Iron Works of Allegheny, Pa., and coming from the makers of one of the highly successful machines of this type on the market, it may be received as of acknowledged authority.

In general, it may be said that as a machine drives by one quick squeeze, the time is not consumed in driving the rivet, but in moving from one rivet to the next.

Merely to show what has been done under exceptional conditions, we quote the astonishing record of 12,000 hot ¾-inch rivets driven in ten hours.

The machine doing this was of the portable type suspended from an overhead runway, and the operator had become most expert in swinging it from rivet to rivet. The next best record we know of is 10,000 rivets in ten hours on similar work.

Ordinarily on boiler work, where the rivet must be steam-tight and well driven, 1,000 or 1,500 rivets might be a good day's work, while on structural work, such as girders, 3,000, 4,000 or more are generally driven, and on such irregular work as trusses, probably 2,000 or 2,500.

The nature of the work is all-important, and these are only most general figures, as each job has its own peculiar conditions.

Speaking of the advantages of the use of concrete in fireproof construction, Mr. Frank B. Gilbreth says that the only excuse for using wood construction is its low cost: To-day—here—now—we have an incombustible material, a material at a less cost than wood, that will stand high temperatures for long periods without injury. Wood must not be used. We do not argue that no other non-combustible shall be used and that concrete shall be used exclusively, but wood construction should be eliminated from all building construction.

The Constitution of Matter

The article by Professor Robert Kennedy Duncan upon the atom in the June issue of *Harper's Magazine* appeared just in time to enable the announcement of the isolation of the ion, by Professor Milliken, to be accompanied with the kind of an explanation which permits the general reader to obtain an idea of the lines along which the modern investigations of the constitution of matter are being conducted.

Professor Duncan examines the relation of the atom to the general theory of matter and explains the work of Rutherford in measuring the force of each ion, or electrical atom, by the employment of the electrometer. This important article is hardly published before Professor Milliken announces from Chicago how, by the use of the air condenser, the X-rays and radium, he has succeeded in isolating the ion, in measuring its speed under the influence of an electrical field and of rendering it visible under the ultra-microscope.

The time is past when the utility of such refined investigations can be questioned, and every such study of the constitution of matter is welcomed, not only for the addition which is made to the sum of human knowledge, but for the aid rendered in guiding the men who are conducting parallel work in applied science. The development of modern electrical machinery dates from the researches of Faraday, researches of which the practical application appeared as remote as those of Rutherford, Perrin and Milliken; what the actual results of the work of these later investigators may be remains to be seen.

In any case, it is a matter of interest to perceive such researches occupying an important place in a literary magazine, discussed by a wholly competent scientist in language intelligible to the layman, and evidently attracting the interested attention of readers to whom formerly such a subject would have been hopeless.

Book News

Producer Gas

American Producer Gas Practice and Industrial Gas Engineering. By Nisbet Latta. Size 8 inches by 11 inches, pp. xviii, 539, 246 illustrations. New York: D. Van Nostrand Company. Price $6.

IT is excellent indication of the growing importance of gas power that such an extensive treatise upon the subject of the production of gas as a fuel, both for power and for industrial operations, is demanded. Mr. Latta has treated the question exhaustively, beginning with an examination of the conditions of gas-producer operation, followed by a discussion of methods of cleaning the gas, of the problems of moving gas and of the physical and chemical properties of gases.

Chapters upon works details, upon the various types of producers, upon gas engines, furnaces, kilns and special industrial applications, give the work a highly practical character. The important subjects of heat and its properties, and of methods of measuring heat, are given separate chapters, while data upon materials and a number of reference tables close the volume. A glossary of terms used in the work and in general discussions of gas engineering forms a useful addition to the work, which is very thoroughly illustrated and fully indexed.

In thus gathering together in one volume the available information up to date concerning industrial gas engineering, Mr. Latta has made a valuable contribution to engineering literature and one which will doubtless do much to extend the use of gaseous fuel, both for power and for metallurgical and other purposes. During the past ten years the gas engine has made amazing strides and units of several thousand horse-power are commercially built and extensively used. The gas producer itself, however, has progressed more slowly, partly because of lack of published data and experience, a lack which is well supplied by this treatise.

Mr. Latta especially disclaims any attempt to recommend any particular apparatus or process; he describes freely and fully processes, apparatus and inventions protected by patent or open to general public use, the basic idea being to illustrate broadly the respective types of apparatus and appliances which are in successful operation at the present time.

The wide extent of the gas industry renders it impracticable, in a work even as voluminous as this, to examine every appliance on the market, and hence a selection has been unavoidable, and this selection has been made with a view of presenting those which are typical of the various classes and emphasize the characteristics of each class most effectively.

The book can be commended as representing as fully as possible in a single work the state of the art of industrial gas engineering at the present time, leaving to specialized works the discussion of details of construction and variants which are necessarily included in the broad divisions of the subject.

Electricity

Electrical Engineer's Pocket Book. A Hand-Book of Useful Data for Electricians and Electrical Engineers. By Horatio A. Foster, with the collaboration of eminent specialists. Size 4 x 7 inches, pp. xxxvi, 1599. Numerous illustrations. New York: D. Van Nostrand Company. Price $5.00.

The new fifth edition of Foster's well-known electrical engineer's pocket reference book comes as practically a new work, the various sections having been either completely revised and brought up to date, or else entirely rewritten.

The original plan of dividing the subject into a number of sections, and having each revised by an eminent specialist in that particular field has again been followed. Aside from the easy accessibility thus afforded, this plan of construction is valuable in proportion to the weightiness of the authorities entrusted with the revision of the several divisions.

An examination of the list of names in the present edition of "Foster" reveals, among others, such authorities as Prof. Samuel Sheldon, Dr. Harold Pender, Mr. Wm. Maver, Jr., Mr. Cecil P. Poole, Dr. F. A. C. Perrine, Mr. Lamar Lyndon, Prof. F. B. Crocker, Mr. Max Loewenthal, Mr. W. Wallace Christie, etc., so that the standard of authority is well indicated.

Among the subjects treated in new sections may be mentioned tables of inductance, capacity and impedance, in the section on conductors; while the sections on street railways, photometry, conductors, lighting, Roentgen rays, etc., are examples of exhaustive though condensed treatment.

Especially worthy of comment, and most important in a book of this sort, is the very complete index, covering 67 pages in itself, while a very full table of contents enables the various sections to be found at once, the two guides thus supplementing each other very effectively.

The book is provided with a marginal thumb index, enabling it to be opened immediately to any section, so that every facility is provided for rendering its contents available.

The pocket reference book has become an essential in any department of engineering, and the enormous growth and activity of the electrical industries has rendered a separate book of this type an absolute necessity. The professions of civil, mechanical and marine engineering have long been provided with valuable reference books, and Mr. Foster and his collaborators have done for electrical engineering what has already been accomplished for the older branches of applied science. The work has been well done, and the book will doubtless meet with the same general acceptance as has been accorded to its predecessors in other portions of the field of engineering.

These special contributors have each dealt with the subject contained in their own fields, thus giving the book a value not possible with a single author, however able.

Consoling Reflections

As for the people who can neither afford to have an automobile nor to go to Europe in the summer, it is a question, of course, whether they are worth discussing. There are a number of them, but they are not much in it. What do you suppose they do with their poor lives? Work, maybe! Well, some one ought to work. We need the money, and it doesn't grow without cultivation.

Perhaps a few words of philosophical condolence may not come amiss to those friends who are deprived of both of the preferred recreations of our people. Dear sufferers, take courage, have hope. There is something to be said for your fate, rasping as it seems. Look at Judge Taft. What a happy and useful and respected man he was as long as he had to scrape along on the meagre salary that our country awards to a Federal judge or a Cabinet officer! But since he got a better job with an allowance for travel and a salary large enough to share with a chauffeur, how many dolorous experiences have befallen him, how many places he has been to when he might have been more profitably employed at home, how many words he has spoken in places far away from Washington that were better unsaid!

After all, man cannot live by transportation alone. Fault used to be found with us Americans because we did not rest and play enough.

The fault that nowadays we may most aptly find with our restless brethren is that they seek diversion so urgently as to be in danger of missing the pith of life. The value of diversion depends on what you are diverted from. There is more to be got out of life by acceptance of it than by avoidance of it. In so far as travel and automobiles carry us deeper into life they are useful, but in so far as they divert us from fruitful living they do us no good.—*Harper's Weekly*.

THE LATEST CATALOGUES

In writing for Catalogues, please mention Cassier's Magazine

Gas Engines

Turner Fricke Manufacturing Company, Sharon, Pa. Illustrated description of the Turner-Fricke gas engine, with data and results of tests made at the fuel testing plant of the United States Geological Survey at the St. Louis Exposition, showing the fuel consumption to be 40 per cent. of that required for steam power.

Wire Rope

American Steel & Wire Rope Company, New York. Large catalogues of data and information for users of wire rope, including new figures of breaking strength based upon averages of different sizes and kinds of rope from actual tests. Information upon the value of lubrication of wire rope is given and price lists and data for hoisting, standing and transmission rope are appended. A valuable publication for the engineer and contractor.

Furnaces

Rockwell Furnace Company, New York. Bulletin M, devoted to the tilting crucible melting furnace and its applications in the foundry for melting aluminum, brass, copper, cobalt, iron, manganese, etc., using either oil or gas as fuel.

Pumps

American Steam Pump Company, Battle Creek, Mich. Illustrated catalogue of the Marsh steam pump, with detailed tables for reference and instructions for setting up and running the various types of pumps. The advantages of the Marsh pump over the duplex type are set forth, and special attention is directed to the satisfactory performance of the Marsh pump for feeding boilers under low-pressure steam.

Motor Car

General Electric Company, Schenectady, N. Y. Illustrated description, Bulletin No. 4730, illustrating the use of the combination of gas engine and electric motor for operating street cars, motor trucks and similar vehicles. This adaptation of electric transmission with the combustion motor enables cars to be operated upon lines to which the overhead or underground conductor is not applicable, or for pioneer work in extensions and development. Details of construction and illustrations of parts render the construction clear.

Truck

American Locomotive Company, New York, N. Y. Bulletin No. 1003, devoted to the radial trailing truck with outside bearings, showing the advantages of accessibility for lubrication, examination, renewal of packing and repairs afforded by this design. The superior riding qualities of the truck are set forth and its satisfactory performance in operation and maintenance.

Conveying Machinery

Jeffrey Manufacturing Company, Columbus, Ohio. Booklet No. 38, illustrating the general character and wide range of the products of the manufacturers. Attention is called especially to the fact that special catalogues are issued describing the various lines of these products, including storage battery and other industrial locomotives, Jeffrey wire cable conveyors, wire cable hauls, Jeffrey drop-rail mine cages, coal tipples and screens, coal washeries, revolving screens, centrifugal mine fans, crushing and pulverizing machinery, conveyors for lumber and pulp mills and rubber belt conveyors. Any of these catalogues will be mailed upon request.

Feed-Water Heaters

THE BLAKE & KNOWLES STEAM PUMP WORKS, New York. Bulletin B. K. 843, describing the advantages of the open type of feed water heater, with exterior and sectional views, specifications and information necessary in determining the proper apparatus for a given service.

Electric Power

TRIUMPH ELECTRIC COMPANY, Cincinnati, Ohio. Electricity in a Modern Bakery. An interesting description of the application of the Triumph electric motor for operating machinery in the bakery, showing the convenience, cleanliness and economy of electric power for this service. The motors are used for all details of the work, including coring, peeling, slicing, chopping, egg-beating, dish washing, etc., with a marked reduction in the number of employees required and consequent reduction in expense.

Electric Power

CROCKER-WHEELER COMPANY, Ampere, N. J. Three bulletins devoted to the products of the manufacturers; Bulletin 119 illustrates the large engine type of direct-current electric generators, showing their economy, simplicity and ease of control; Bulletin 121 sets forth the advantages and efficiency of the small engine type of direct-current generators for hotels, department stores and office buildings; Bulletin 124 is devoted to exhaust fans, discussing the importance of reliability in continuous and efficient operation, especially as regards commutator troubles.

Featherweight Engines

ELBRIDGE ENGINE COMPANY, Rochester, N. Y. The folder published by this firm deals with light gasoline engines built especially for aeronautical work. The experience gained in building marine engines has been successfully used and modified in the construction of aeronautical machines.

Bolt Machinery

ACME MACHINERY COMPANY, Cleveland, Ohio. Catalogue for 1910 calling attention to the special points of excellence of the Acme bolt and nut machinery. The durability, simplicity and strength of the Acme die head are emphasized, while the methods of manufacture, including the employment of standard gauges, assurance of interchangeability, high grade of material, etc., are also set forth.

Valves

WALWORTH MANUFACTURING COMPANY, Boston, Mass. Booklet illustrating and describing all kinds of supplies for use with steam, water and gas. The importance of high qualities in such details and the false economy in purchasing cheap valves and fittings are discussed, and price lists of the Walworth products are given.

Air Brakes

NATIONAL BRAKE AND ELECTRIC COMPANY, Milwaukee. Bulletin No. 389, devoted to the three types of emergency brakes made by the manufacturers, showing how the straight air brake is operated with the emergency valve unchanged, and how the latter valve comes into action when needed. The details of construction are shown in numerous diagrams and the method of releasing the brakes is described.

Separators

POWER PLANT SPECIALTY COMPANY, Chicago, Ill. Catalogue of the Vater two-stage separator for removing entrained water from steam. It is claimed for this device that it will remove water or oil from steam which has already passed through separators of other types, while a reversal of the operation will show that the Vater apparatus has already done the work.

The Value of Silence

WE have referred elsewhere in this issue to the various methods of increasing efficiency by avoiding the consumption of energy in the production of useless or undesirable effects, and called attention to the cost of the production of noise. This is a point which cannot be emphasized too strongly, and it is gratifying to observe that in modern installations of machinery of types which formerly were considered necessarily noisy the value of noiselessness is taken into account.

Probably the handling of coal, broken stone, ashes, cinders and similar substances is an operation associated in the minds of nearly everyone with the concomitants of noise and dirt. This is doubtless because of the recollection of the days when such handling was really performed by hand, and when such materials were moved about by muscular effort, using the ordinary shovel as the principal tool.

The proportion of waste energy to useful effort in the act of shoveling a broken material, such as coal, for instance, is large. The material is taken up with difficulty and thrown some distance, producing noise, and being partly broken up and disintegrated, with the formation of considerable dust and consequent impairment of its value. These effects are wholly undesirable in themselves, and account for a large proportion of the wasted power.

The production of dirt is in itself injurious, both to the structure in which the work is done and in the surroundings, and it also acts to lower the efficiency of the men themselves; no man can do his best work in the midst of grime and grit. There is thus a lowering in efficiency in the original production of the effort and a further loss in its subsequent application. If cleanliness and quiet can be substituted for dirt and noise, there should be a marked increase in the efficiency of the operation; and if, to these advantages, the effort of human muscle may be replaced by the highly efficient electric motor, there should appear a still further improvement in the efficiency of the entire operation.

That there is such an advantage in the substitution of modern handling machinery for human labour is evident by the extent to which such machinery has replaced men in the great proportion of the large power plants for the handling of coal and the removal of ashes.

Anyone who goes into such a power plant will observe the comparatively small number of men employed, and yet he knows that a very large quantity of coal is being consumed and converted into power. That this coal must be got into the building somehow and fed under the boilers, is understood, and it is also realized that the ashes must be removed continuously. If the coal were dumped into bins in a manner similar to that used for household deliveries of fuel, the noise would be almost deafening; but no such disturbance of the air is apparent. Upon investigation, however, the visitor finds that there is a continuous flow of coal from the barges or cars by which it is delivered to the storage bins above, and from the bins to the mechanical stokers in the furnaces, and that all this work is being performed with so little noise and with such an absence of dust that he has to look about him to find out just how it is done. In like manner, the non-combustible portion, in the form of ash, is removed in such a quiet and cleanly manner that it is hardly apparent, either as to method or location.

That such a system is necessarily far more efficient than the old-time noisy, dirty, wasteful combination of laboring gang and shovels is apparent in itself; that it has been actually demonstrated to be so, is evident by the extent to which the machine has replaced the man, not only in the power house, but also in the iron works, the steel mill, and the manufacturing establishment.

Unity in Power-Plant Design

IT has been said of the old-time machine shop that it was not planned beforehand, but that it "grew," and that it generally grew along lines which were not those of greatest efficiency, but those of least resistance. That is, an establishment with small beginnings developed as the business was prospered, by the erection of additional buildings on the most convenient adjacent ground, and power was either sent by shafting, belting or rope from the old engine room, or else another engine was installed in the new buildings. When, later on, further extensions became necessary, they were placed where the ground could be acquired, and the operation repeated until the entire plant resembled a sort of village, or aggregation of structures, by no means such as would have been erected had the whole establishment been planned from the beginning.

In like manner, the question of the distribution of the power through such a works was effected in the manner most convenient at the time, and hence by no means according to methods which would have been employed if a general scheme had been planned out in advance.

Often the above procedure was the best which could be used under the conditions, and the use of a predetermined layout for the final result would have been impracticable. At the present time, however, the construction of great manufacturing establishments from the start has become a distinct branch of engineering work, and the result is the design of the entire establishment, as complete in detail as is the case with a great ocean steamer or a metropolitan skyscraper.

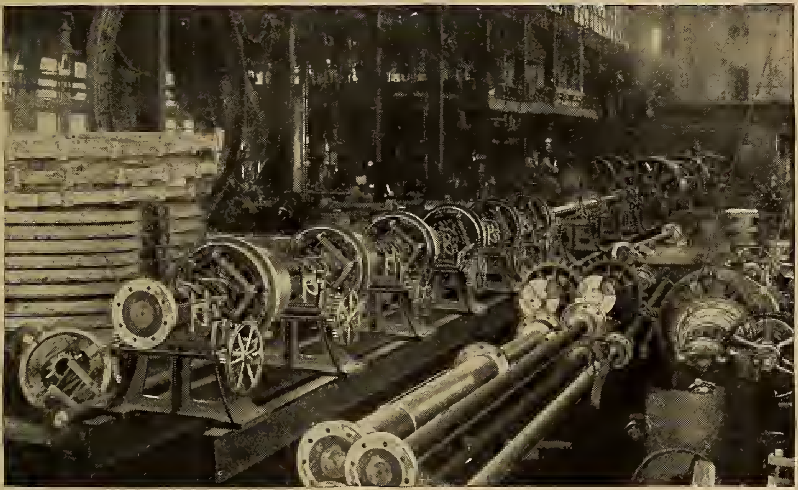
In no department of such a plan is more attention demanded than in the design of the power-transmission system. Next to the generation of the power, to the boilers, engines, and details of the power house, comes the delivery of the power from the centre where it is generated to the extremities where it is utilized. A considerable portion of the power must necessarily be consumed in the journey from the engine to the tool; how much is thus absorbed depends very largely upon the manner in which the transmission is planned, how well it is adapted to the special conditions which exist, and how accurately the plans of the experienced engineer are executed in the construction.

In the consideration of the generating portion of the power plant the greatest care is taken to secure coordination of the various elements. The amount of power to be used is carefully determined, as well as the quantity of steam demanded for other purposes. The boiler capacity and the dimensions of the engine are thus intelligently settled, and in like manner the system of piping, water supply and other essentials are worked out. The modern manufacturer of power-transmission equipment follows out similar methods. The situation of the various parts of the plant are studied to determine whether shafting, belting or rope-drive is to be recommended. The amount of power demanded in the several operations is estimated, and has an important influence upon the choice of methods and dimensions, and when the whole has been laid out it is constructed in the light of long experience, and then assembled, tested, and its completeness assured before it is finally erected in position for service.

It is evident that such a procedure must result in the attainment of a far greater degree of efficiency than is possible in any hap-hazard growth, building up department by department, often with no other guide than the rule-of-thumb, and frequently with no adequate determination of the actual requirements of the situation. The modern method is both efficient in itself and makes for higher efficiency of the men by whom it is operated, and it marks one of the forward steps in mechanical evolution.

DODGE

The Factory Power Transmission System Should be a Complete Unit—Properly Designed and Tested



Outfit of Shafting, Dodge Friction Clutches, Bearings and Pulleys under running test on our assembling floor

NO satisfactory service would be expected from an engine if the frame were bought here, the cylinder there, the piston and other parts picked up elsewhere, and assembled on the ground.

¶ And the outfit which transmits, is as important as the engine that generates the power.

¶ Complete equipments of Dodge Transmission Machinery represent the greatest possible efficiency. Our engineers design Dodge outfits for the particular service which they are to perform.

¶ And, in addition, every special equipment is assembled and put under a running test in our shops. No less a try-out will demonstrate the absolute accuracy of all the parts of the outfit.

¶ Please consider what this kind of tested, established efficiency means in economy of quick erection — how it eliminates friction loss in operation and reduces the expense of renewals and attendance.

¶ If you contemplate the installation of power transmission machinery, or if your present power distribution system is uneconomical, write us. We can help you secure efficiency.

¶ Send for our new complete general catalog CC-10, "Power Transmission Engineering" and other information on this subject.

DODGE MANUFACTURING COMPANY

STATION F-11, MISHAWAKA, INDIANA

New York	Chicago	Philadelphia	Minneapolis	Atlanta
Pittsburg	Boston	Cincinnati	Brooklyn	St. Louis

Agencies in the Other Principal Cities of the Country

The Cost of Noise

NOTHING which demands the consumption of energy for its production can be had without cost; noise must be paid for in hard cash without the satisfaction of receiving any useful return; it is a sort of frictional resistance, consuming power for its production and at the same time impeding the efficiency of everything with which it is associated.

Under such circumstances, it is surprising that the attention of the engineer has not long ago been directed toward the desirability of producing machinery which should waste the minimum of power in the emission of wasteful noises, and thus leave a larger proportion of energy available for useful work.

Attention seems to have been turned toward this phase of the problem of machine design in a somewhat indirect manner. The noisy machines have been found to be inefficient and those which are smooth and silent in their action have been demonstrated to be efficient in their conversion of power. The car which goes bumping over irregularities in the track, disturbing every one about it in its progress through the shop, naturally requires more effort to move it along than is demanded by the chain block, which, suspended from its overhead tramrail, is moved quickly and silently from one end of the shop to the other.

Formerly heated metal was pounded into shape with much noise and clamor in the smith shop, using the repeated blows of many hammers, which approximated pandemonium in the multitude of sounds indicating the useless consumption of power. To-day the silent hydraulic forging press shapes the metal with a noiseless squeeze, in which the quality of the product is benefited by the absence of impact effects and the presence of concentrated, steadily applied energy. In like manner the pressure riveting machine has, in many instances, replaced the noisy blows of the hammer, and in numerous similar cases the suppression of noise might be associated with the improvement in the resulting product.

The waste of energy appears in many mechanical operations as a result of primitive methods of doing things which have not been adequately studied, but, instead, have been inherited from earlier practices.

The smith makes many useless blows upon the anvil, and the bricklayer waves his trowel in the air, and includes various gesticulations in connection with the really effective movements of his work. These may not be accompanied with the production of noise, but they involve waste of energy none the less, and proper training would enable many such useless motions to be replaced with others of valuable effect.

In the case of the chain block, the efficient machine is that which permits the operator to assume the most effective position, to make the fewest unnecessary movements and to expend the minimum amount of effort in overcoming frictional resistances. When the burden is lifted, it may be conveyed through the air in silence at an expenditure of a trifle of the power required to drag it along the surface of the ground, while the effort involved in lowering the load to the required position is again a minimum. By thus making a thoroughfare in the air, all obstacles are overcome, the resistances are kept at the lowest point and the production of noise is entirely avoided.

Apart from the advantages thus obtained in the actual handling of parts during the operations of machining, the use of the silent overhead means of transport enters into the accomplishment of important economies in the assembling of the elements into the finished product, cutting down the time and thus reducing the proportion of fixed charges, besides greatly reducing the wear and tear upon the building, and acting broadly to minimize wastes.

Making the Wheels Go Around

MANY years ago the genial author, Dr. Oliver Wendell Holmes, contributed to the *Atlantic Monthly* an article entitled "The Human Wheel, Its Spokes and Felloes," in which he discussed in his inimitable manner the resemblance of the human leg and foot, in the operation of walking, to the rolling of a wheel along the ground. The human wheel was at no time a complete circle, but the alternate movement of the legs provided spokes for support, and the rolling action of the foot furnished a portion of the rim always upon the ground. With the exception of this analogy there appears to be no example of a natural wheel from which our ancestors could have derived the conception, and it seems as if, in some remote period, there must have been an inventor of truly originating genius who produced the first wheel.

Once produced, the wheel has met with an infinite number of applications in the arts, applications the lack of which would almost throw us back into barbarism. We do not attempt to make vehicles in imitation of animal locomotion; we put them upon wheels and cause them to roll smoothly upon roads or rails. We do not even try to apply the reciprocating motion of the steam engine to the direct performance of mechanism, except in such isolated examples as the steam hammer and the like, but set it to work making a wheel go around and then pass this rotating movement on and on and on to other wheels, until the actual point of conversion of energy is reached. Even then we endeavor to perform the work itself by rotary motion if possible, and do as much as we can with the lathe, the boring mill, the drill and the milling machine.

Under such circumstances it is apparent that the production of power-transmitting machinery necessarily involves the design and manufacture of wheels of all kinds, wheels for belts, for rope, for speed regulation and for combined applications.

Formerly the making of a pulley or a fly-wheel was a rather complicated operation, and much care and labour had to be expended upon a pattern for each particular case, labour which usually had to be done over again for the next job. To-day the manufacturer of transmission machinery carries a line of patterns and parts, or is provided with special molding machinery which enables him to manufacture rather than to make, and the product is superior to that which cost so much more. When the function of a wheel is to pass along the force which is in motion about its rapidly speeding rim, it has been found desirable to keep the weight down, to increase the tractive friction of belt or rope, and to facilitate placing it in position; in other words, the split pulley of wood or with wooden rim appeared and has persisted.

When speed regulation was the object of the wheel, it became a fly-wheel, and the weight of the revolving rim, the inertia of which was to oppose fluctuations in impulse or in resistance, became the important element, until engineers found that the resistance of centrifugal stresses at the increasing speeds demanded the critical attention of the skilled engineer. The design and construction of fly-wheels thus entered into the domain of the manufacturer of transmission machinery.

The greater includes the lesser, and the wheels of mechanism require shafting for support and for extension of movement, besides bearings, supports, clutches and couplings. The velocity of the rim of the pulley has to be passed on from wheel to wheel, and the flying belt of leather or rubber or the multiple coils of manila rope are used, and thus the task of making the wheels go around occupies the highest efforts of the able engineer, the skilled mechanic and the commercial administrator in the conduct of the work of the world.

Stone Quarrying to Specification

IN comparing the rate of production of a modern manufacturing establishment in almost any line of activity with that of one of the shops of the olden time, with its obsolete means and methods, the comparison always being of course for the magnification of the former, we are apt to omit some of the essential particulars, the omission leading us to unwarranted conclusions. A locomotive works, for instance, for a given force employed, will now turn out many times the number and value of engines which would have been possible half a century ago. Upon investigation it will soon appear that all the improvements in machine efficiencies and in the details of shop manipulation do not nearly account for the vast increase in output. Every shop in these days not only has its own force busily employed, but it also has many hands in many factories variously situated producing the minor details of the assembled machines which it turns out. Besides the enumerated force of workmen in the shop itself, there are probably many more than that number in other shops who are preparing material and manufacturing the numerous "supplies" which the shop requires and uses to complete its work.

This same distributing and specializing of activities, while concentrating their results, applies in larger enterprises than those of the shops. The greatest of all industries is the building of cities, and none, perhaps, has had a greater transformation. The modern building methods are most rapid and prolific, because here the practice is now similar to that of the shops. The building of New York, for instance, is going on, not in New York alone, but in various places throughout the land. Practically all the vast structures which we are continually piling up higher and higher are really manufactured elsewhere, Manhattan witnessing only the final assembling of the parts. Most of the building of the sky-scraper is done at the steel works, and at the stone quarry, and the several pieces, whether of steel or of stone, come already fitted and marked and numbered, to show how they go together.

In machine work, and all through the metal industries, the automatic screw machine, which, as we all know, turns out a vast variety of small machine parts besides screws, is perhaps the greatest individual helper, and in stone work the channeler finds equally wide employment and accomplishment no less prolific.

The channeler emphasizes perhaps more completely than any other device the difference between ancient and modern practice in stone work. The channeler is not as yet capable of working some of the harder stones, but in the vast field which it does cover it represents the cutting of stone to precise dimensions.

We are quite in the habit of saying that Egyptian architecture called for massive blocks of stone, but the simple fact is that the method of quarrying produced big stones and the architect was compelled to adapt his designs to the material as it came to him. The quarries of Egypt even to-day tell clearly the story of the splitting off of the stones by the cutting of rows of holes of no great depth and the swelling force of the wooden blocks which tightly filled them. It is often said that we could not now get out and transport the stone masses of ancient Egypt. It simply would not pay and would not be worth while for us.

If we could not reproduce the temples of Thebes, still less could the builders of Thebes have produced the Metropolitan Life Building of New York, the largest marble structure in the world, and the most complete embodiment of the work of the channeler. After the Tuckahoe marble was decided upon for the material, the quarry could in no other particular dictate to the architect. The blocks in shape, dimension and detail of decoration were determined in the office, and the drills and channelers and pneumatic tools produced them precisely as ordered.

Steel Window Frames

THE effort to eliminate the immense waste of property and value due to fire losses has led to the development of fireproof construction, an effort which has been immensely aided by the increasing use of concrete, both plain and reinforced, in building construction.

The constructing engineer, in his search for fire-proof materials, had been led to abandon certain natural stones, which either crack and break under the action of heat, or are so materially reduced in strength as to render their continued use a matter of uncertainty. He has also found that the true fire-proof materials are those which have already been through the fire, and have consequently been tested and have developed the resistance to heat which is absolutely essential. Thus brick, cement, cinder, etc., together with certain other materials such as sand, certain kinds of stone, and, in general, the materials of concrete, are available within their structural limitations.

When the use of reinforcement of steel, imbedded within the concrete structure, was found to give the necessary tensile resistance, the field for genuine fire-proof construction was opened. The steel necessary for strength could be so protected from heat as to remove its former weakness under the action of fire, while the wide applicability of concrete made it possible to abandon the use of combustible wood almost entirely.

The one detail in building construction for which wood retained its usefulness for some time appeared in the construction of window framing and sash. Concrete was here inapplicable, while the earlier attempts at the production of steel sash resulted in forms by no means so desirable as the wooden ones then in use.

A steel sash must be as light in weight as is consistent with strength, and it must offer the minimum obstruction to the passage of light. It must be stiff enough to resist the pressure of heavy wind and strong enough to carry the weight of heavy glass. With these fundamental requirements come also those of tightness against weather and provision for ventilation.

To meet these conditions means that the sash must be manufactured according to mechanical principles, using rolled sections specially designed for the purpose to insure lightness, strength and proper methods of junction. It involves standardization of sizes, forms and construction, to meet the requirements of the architect, owner and builder, and to permit the use of proper sizes of glass. In short, it takes the manufacture of the sash out of the scope of the woodworking mill, and compels the organization of a metallic sash manufacturing industry.

Such a development completes the possibility of the fire-proof building and removes the last reason for the employment of any combustible material.

It also removes what has repeatedly been shown to be a serious menace to a building from without. It is of small avail for one owner to be careful in using fire-proof construction if the fire in his neighbor's property can enter through his windows and work internal damage to the building in which the fire could not have originated.

There are numerous examples of fire loss of just this kind, losses against which no amount of care could provide so long as combustible window frames left the vulnerable point for the external fire to work its harm. The careless or unwilling neighbor constitutes an enemy, so far as fire risk is concerned, against which the steel sash and window frame forms a defense, and with such protection safety is assured.

Thus the steel sash and window frame becomes the final element in the completion of the modern fire-proof building and enables what has hitherto been the weak point as effective as other parts of the structure.

Manufacturing News

The History of the Rock Drill

BY W. L. SAUNDERS

THE rock drill is an American invention, conceived and developed in the United States. J. J. Couch, of Philadelphia, took out the first practical patents in 1849. In his experiments he was assisted by Jos. W. Fowle. The Couch drill was a crank-and-flywheel machine.

Couch and Fowle separated in 1848, the latter filing a caveat in 1849 covering a drill of his own invention and describing the successful power rock drill substantially as it is to-day. The most important feature of Fowle's drill is that the cutting tool was attached directly to the piston. In other words, the steel leading into the hole was an extension of the piston rod.

Fowle described this invention in his testimony before the Massachusetts Legislative Committee in his contest with Burleigh in 1874, as follows:

"My first idea of ever driving a rock drill by direct action came about in this way: I was sitting in my office one day after my business had failed and happening to take up an old steam cylinder, I unconsciously put it in my mouth and blew the rod in and out, using it to drive in some tacks with which a few circulars were fastened to the walls."

In Europe, the nearest approach to rock drill invention was the work of the German, Schumann, carried on in 1854. Fowle being without means to develop his ideas, they remained in obscurity until Charles Burleigh purchased his patents and produced the Burleigh drill, about 1866. This drill was used in 1867 in driving the Hoosac tunnel in Massachusetts.

Following Couch, Fowle and Burleigh, came Haupt, Wood, Ingersoll, Sergeant, Waring and Githens. Githens was the inventor of the Rand drill.

The Ingersoll drill was invented in 1871. Simon Ingersoll, a modest, ingenious and honest mechanic, came to New York from Connecticut, bringing with him the models of several inventions. He was riding in a New York horse car one day and was describing one of his inventions to a fellow passenger. Another passenger in the car was John D. Miner, who overheard Ingersoll's conversation. Miner was a contractor, engaged with a gang of men on some rock excavation in New York City.

Miner broke into the conversation to ask Ingersoll why he didn't invent a rock drill, telling him that he had a gang of men at work striking a steel with a hammer to make a hole for blasting; that they could put in only

about ten feet of hole per day, and that he did not see why a machine could not be built that would do the work.

Ingersoll said he could make such a machine and would go at it at once if he had the money. Miner gave him fifty dollars and his card, saying that though he had never seen Ingersoll before, he had an honest face and he would trust him to spend that fifty dollars in building a rock drill. "When you want any more," said Miner, "come to me and I'll give you another fifty."

Ingersoll's first rock drill was built in a shop at Second avenue and Twenty-second street, New York City, owned by J. F. de Navarro, and was managed by Sergeant and Cullingworth.

One day Henry C. Sergeant saw the patterns for Ingersoll's drill. He noticed that the front head was attached to, and was a part of, the cylinder. He told the workmen that they should be in two pieces, and proceeded to saw off the pattern. At this point Ingersoll came into the shop. "What are you doing?" he asked. "I'm making this thing practical," said Sergeant, as he finished cutting off the pattern before Ingersoll could stop him. The result was the first row between Ingersoll and Sergeant and it led later to Mr. Navarro purchasing, on Sergeant's advice, all rights and patents held by Ingersoll. The Ingersoll drill was made with the separate front head as used to-day.

Mr. Navarro organized the Ingersoll Rock Drill Company, investing $10,000 in the concern. Litigation arose with Burleigh, of Massachusetts, who owned the rights of Fowle and others. However, Mr. Navarro's plentiful supply of funds and his liberal nature brought about a settlement of the suits, and all the patents became the property of the Ingersoll Rock Drill Company.

The business quickly paid back to Mr. Navarro the $10,000 he had put into it, and in later years he sold his interests to Mr. R. W. Chapin for $525,000. Sergeant sold out because of friction with the management, went West, engaged in mining, returned to New York about 1885, and organized the Sergeant Drill Company.

Early in rock drill developments the Rand brothers, Addison C. and Jasper R., had become interested through their connection with the Laflin and Rand Powder Company. Addison C. Rand formed the Rand & Waring Drill and Compressor Company, later controlled exclusively by Rand and merged with the Rand Drill Company, established in 1871 and incorporated in 1879.

J. C. Githens, superintendent of the Rand Drill Company, invented the "Little Giant" rock drill. He was the originator also of many improvements, notably the double-screw column with column arms, which made practical the application of the rock drill to mining and tunneling.

The Sergeant & Cullingworth Company manufacturing the Ingersoll drill, the Sergeant Drill Company, and the Ingersoll Rock Drill Company, were merged into the Ingersoll-Sergeant Drill Company. Later on the Rand Drill Company and the Ingersoll-Sergeant Drill Company were consolidated in the Ingersoll-Rand Company, to-day carrying on the business of all these pioneer concerns. The Rand drill from the beginning had been the most formidable competitor of the Ingersoll and Sergeant types. The conjunction of the Ingersoll-Sergeant and Rand companies, therefore, was a combination of valuable patents in rock drills, compressors and general machinery for mining, tunneling and quarrying. Each shop received the benefit of the experience of all the others, and the best features of the Ingersoll, Sergeant and Rand types were taken to make an improved product.

The present company, capitalized at $10,000,000, sells its product throughout the world. Its machines are the recognized standards in their line, and its constant endeavor is to maintain its standards up to, or even in advance of, the times.

APPLICATION OF MICROMETER GAUGE TO RAMBLER BEVEL GEAR TO DETERMINE ITS ACCURACY.

Manufacturing Methods in the Rambler Automobile Works

THE Superintendents and Foreman's Club of Chicago, an organization of eighty-five members, composed of the managers of the greatest mechanical plants in the Middle West, all experts in advanced mechanics, recently visited the plant of Thomas B. Jeffery & Co., at Kenosha, to study the system of advanced physical and chemical tests employed in determining the quality and efficiency of Rambler parts and to watch those methods by which standardization of parts has been attained through extreme accuracy in workmanship and the rigid inspection system which the Rambler people maintain.

These experts followed the production of the Rambler from the drop-forge shop, where a battery of steam forges make every drop-forging, from the smallest valve stem to the largest crankshaft, to the body finishing and inspection department, where every Rambler body is made complete and finished in the most minute detail.

A special study was made of the methods employed in standardizing Rambler parts and making all interchangeable through careful grinding and finishing processes, assuring absolute accuracy. They observed the processes for treating and hardening metals for all important parts, such as gears, and inspected the Rambler laboratory, where infinite labour is expended over uniform horse-power formulæ, chemical tests of materials and torsion tests of all parts which are subject to strains.

Quality in an automobile and the final satisfaction to be obtained from its use depends not only upon the quality of the materials entering into it, and upon the design, but, more than anything else, upon the accuracy with which the parts are made and fitted. Such accuracy is the product of skilled as opposed to unskilled workmanship.

In the effort to improve the silent and smooth-running qualities of the car, manufacturers are constantly striving to lessen friction wherever friction is possible.

In these factories where standard cars are made, particularly in the

EXPERT WORK IN GAUGING RAMBLER PARTS FOR ACCURACY.

new Rambler factory, special equipment is used and experts are employed to insure accuracy in the making and fitting of parts.

Blanks for Rambler transmission gears are hammered out in the Rambler forge shop, and are so cut and finished as to be noiseless. The ordinary method of making but one finishing cut on a bevel gear is here improved by making two cuts. The gears are tested for silence before being assembled, and the most delicate instruments for attaining accuracy are used.

Piston rings are ground both on the face and sides. The pistons themselves, cams and cam-shaft bearings, all ball cones and cups, roller bearing sleeves and roller bearing cases and gears, are ground in the same way. In some cases even grinding processes are not considered accurate enough. The crankshaft bearings are hand burnished to a mirror-like finish, and no one bearing differs from another more than one-thousandth of an inch. Pistons and cylinders are finished with such accuracy that if they vary one-thousandth of an inch they cannot pass the exacting Rambler inspection. Every piston is fitted to its cylinder with allowance for expansion of just three-thousandths of an inch. The maximum variations permitted in any part is one-thousandth of an inch. In some cases the restriction is carried to the extent of a ten-thousandth of an inch.

By an instrument used only in the Rambler factory it is possible to de-

APPLICATION OF INDICATOR TO DETERMINE VARIATION BETWEEN GEAR CENTRES.

termine if any point on the fly-wheel rim is heavier than another and how much. This means perfect balanc-

SPECIAL GAUGE APPLIED TO RAMBLER BEVEL GEAR.

ing. Every fly-wheel assembled with a crankshaft and all motor parts are thus balanced.

No workman is permitted to fit Rambler bearings who has not had at least seven years' experience.

Each bearing is hand-scraped, and then, by a rolling process, the metal is compressed to close up the pores, after which it is given a mirror-like finish.

The Rambler crankshaft, although adjusted to a snug fit in 80 square inches of bearing surface, will, if revolved by turning the fly-wheel before the connecting-rods are attached, spin freely.

The accompanying illustrations give some indication of the care and skill which is given to the inspection and testing of the various parts of the Rambler automobile during the course of manufacture.

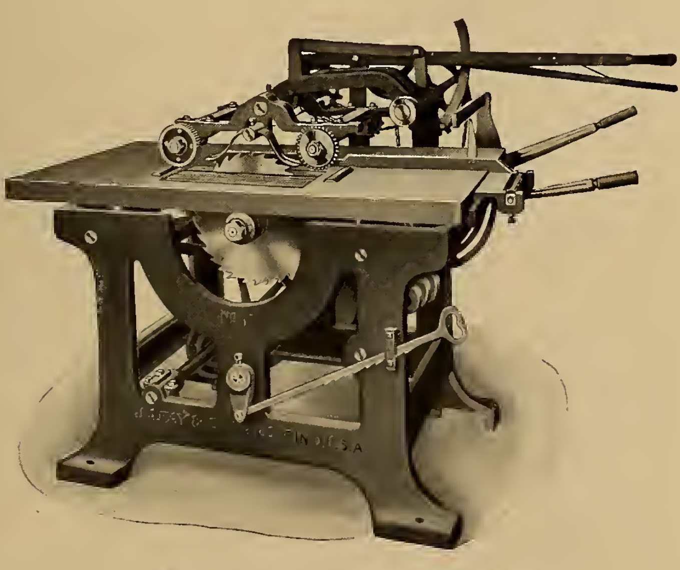
A Modern Self-Feed Rip Saw

WE illustrate herewith one of the most popular woodworking machines manufactured by the J. A. Fay & Egan Company, this being designed to meet the requirements of any shop for a medium self-feed rip saw having capacity for material 18 inches wide and 4½ inches thick.

Some of the valuable features which have contributed to the popularity of this machine are the adjustment of the feed rolls to and from the blade, permitting the handling of very short as well as long stock. The rolls can be instantly lifted to accommodate various thicknesses of stock, and a spring hold-down is provided for preventing short pieces from kicking back. Another important feature is the 3½-inch vertical adjustment of the table instead of the mandrel for various thicknesses of stock. The machine has a throat plate, to permit the use of cutter heads and grooving saws.

The mandrel is made of the best grade of crucible steel, and carries a 16-inch saw. It has a space of 3½ inches between stationary and loose collars, for the purpose of using more than one blade when it is desired to saw lath stock, etc.

A large illustrated circular of this machine will be sent upon inquiry of the makers, the J. A. Fay & Egan Company, 226-246 West Front street, Cincinnati, Ohio.



THE FAY & EGAN NO. 110 SELF-FEED RIP SAW

THE HAMILTON AEROPLANE PASSING OVER THE TRENTON IRON WORKS ON THE FLIGHT FROM NEW YORK TO PHILADELPHIA.

(From a Photograph Made by Mr. William Hewitt.)

The Aeroplane Flight from New York to Philadelphia

ONE of the interesting features about the flight of Hamilton, on his Curtiss aeroplane from New York to Philadelphia, was the fact that he did not hesitate to pass directly over manufacturing establishments, railroad tracks, and other surface occupants, regardless of the dangers which might accompany an involuntary descent under such circumstances.

This is indicated by the accompanying photograph, which was taken as a snap-shot by Mr. William Hewitt, M. Am. Soc. M.E., as the aeroplane, carrying its daring occupant, passed over the works of the Trenton Iron Company. Mr. Hewitt was informed that Hamilton was in sight, and, immediately securing his camera, succeeded in obtaining two good negatives, one of which we have reproduced herewith. It is interesting to note that the machine which thus has succeeded in passing through the air without any other support than the resistance of the air itself, passed directly over a Trenton overhead tramway, the nearest attempt at aerial transport which existed prior to the practical achievement of aerial navigation.

The Bristol-Durand Averaging Instrument for Circular Chart Records

THE Bristol Company, of Waterbury, Conn., have for the last twenty years made a specialty of manufacturing automatic recording instruments for pressure, temperature and electricity. Many thousands of these instruments have been put into practical service. As this class of recording instruments using circular charts have come into general use there has developed a demand for a simple device to quickly determine the average of the record made on such charts and the integral value for the whole twenty-four hours or for the time covered by the record.

This demand has been filled by the instrument illustrated herewith, which is based upon a fundamental plan as worked out and patented by Professor W. F. Durand, of Stanford University, and is constructed in accordance with a novel design recently patented by Wm. H. Bristol, president of the Bristol Company.

The instrument can be applied for averaging records of any kind on circular charts having uniform graduations, as, for instance, records of watts, amperes, temperature, pressure, etc. Recording instruments

THE BRISTOL-DURAND AVERAGING INSTRUMENT FOR CIRCULAR CHART RECORDS.

equipped with circular charts are, therefore, made available for a number of applications for which it was previously thought necessary to use the instruments recording on straight lines or strip record charts. Recording differential pressure gauges are coming into use for measuring velocities and volumes of liquids, air or gas flowing in mains, and this integrating device will prove of value for quickly obtaining total volumes of flow for any given period of time.

The simple construction of the instrument is shown in the accompanying illustration. A wooden base with a metal socket is provided for supporting and centering the chart. The socket holds a rotatable pin with a vertical slot at the top to receive the bar which carries the integrating tracer point and triangular support. The vertical groove in the rotatable pin allows the integrating wheel to roll on the chart with uniform pressure, due to its own weight.

The integrating wheel is 6 inches in diameter, the rim being graduated into one hundred numbered equal spaces, and is fitted with a vernier, which makes it possible to easily read with the naked eye to one-tenth of one division on the integrating wheel. The wheel is of such large size that it is not necessary to supply any counting device for the number of revolutions. The number of complete revolutions cannot be more than two, even for a record of maximum size on the large 12-inch charts.

To operate the instrument, the thumb and forefinger of one hand are applied to the base of the triangular support, which is moved radially, so as to cause the tracer point to continually follow the record curve, while the chart is turned with the other hand.

By referring to a line plotted on a sheet of cross-section paper furnished with the instrument for the particular record curve that is to be measured, the total reading for the entire twenty-four hours may be taken off directly.

A full explanation of the theory

upon which the operation of the instrument depends has been given by Professor Durand, in a paper presented at the New York meeting of the American Society of Mechanical Engineers in 1908. This may be briefly summarized as follows:

In applying the instrument it is necessary to have a uniform radial scale, from which it follows that equal increments in the length of the radius correspond to equal increments in the watts, amperes, temperature, or whatever quantity is measured.

The integrating wheel, being carried at right angles to shaft passing through the centre, does not turn and give a reading when the tracing point is moved on a straight radial line, but if the tracing point is made to follow a record, the integrating wheel will revolve and the amount of the revolution will correspond to the total of the circumferential elemental components of the record curve, the radial elemental components of the record having no turning effect on the integrating wheel.

As the lengths of the arcs of concentric circles for given angles, or for the entire circumference, are proportional to their radii, it is evident that the amount of turning of the integrating wheel, and the reading obtained thereon, will be proportional to the average radius of the record traced.

The instrument is adapted for integrating charts with either straight or curved radial time arcs. The correction necessary for radial time arcs which are curved may be made, after completely tracing the record, by returning the tracing point to a point on the chart having the same radius as the starting point, the movement of the tracing point being along an arc corresponding to the curved radial time arcs.

This instrument supplements the Amsler planimeter very effectively, in that it enables areas to be determined which are beyond the scope of the older instrument.

News Items

Among the recent orders received by the Nernst Lamp Company were four from the wholesale establishment of Marshall Field & Co., Chicago, aggregating 888 glower units. All of the lamps are of the multiple glower type, and special finished housings are used. This firm installed its first Nernst lamps in December, 1907, the same year of the installation of 12,000 glower units in the retail store of Marshall Field & Co., and has frequently since placed orders for Nernst lamps to replace other lamps.

The Nernst Lamp Company, of Pittsburg, received during the month of May an order from the Banks Business College, of Philadelphia, for an installation of Westinghouse-Nernst lamps for the illumination of its new quarters.

The American Street and Interurban Railway Association announce that their annual convention for 1910 will be held at Atlantic City, N. J., October 10 to 14, inclusive.

Mr. George B. Foster has recently been appointed Chicago sales manager for the Wisconsin Engine Company. His office will be located in the Fisher Building.

An indication of the great increase in manufacturing activity during the past year is shown in the report of the Westinghouse Machine Company at the annual stockholders' meeting recently held. This report showed, among other large increases in the volume of their business, 85 per cent. in shop orders received, 48 per cent. in billing in their shop product, and a net addition to their surplus, after deducting depreciation and interest charges, of $429,566.61, as compared with a loss of over $228,000 during the previous year—a betterment over that year of $657,690.15.

THE REGAL AUTOMOBILE AFTER THE RUN FROM ATLANTA TO NEW YORK.

A Reliable Automobile

IT is generally recognized that the real satisfaction to the owner in an automobile lies in the assurance which he has of the reliability of his machine. It was this which gave such interest to the National Highway Good Roads Tour conducted from Atlanta to New York City under the auspices of the New York *Herald* and the *Atlanta Journal* from June 6 to June 13 of this year.

Among the cars which made the run successfully we illustrate the Regal car, No. 8, a machine which, while not awarded a perfect score technically, made one of the most satisfactory runs over roads which were at times almost impassable because of heavy rains, etc. No adjustments of any kind were made upon this car, the only troubles during the entire run being those due to the tires, and upon its arrival in New York the occupants of the car were profuse in their praises of the splendid showing which it made.

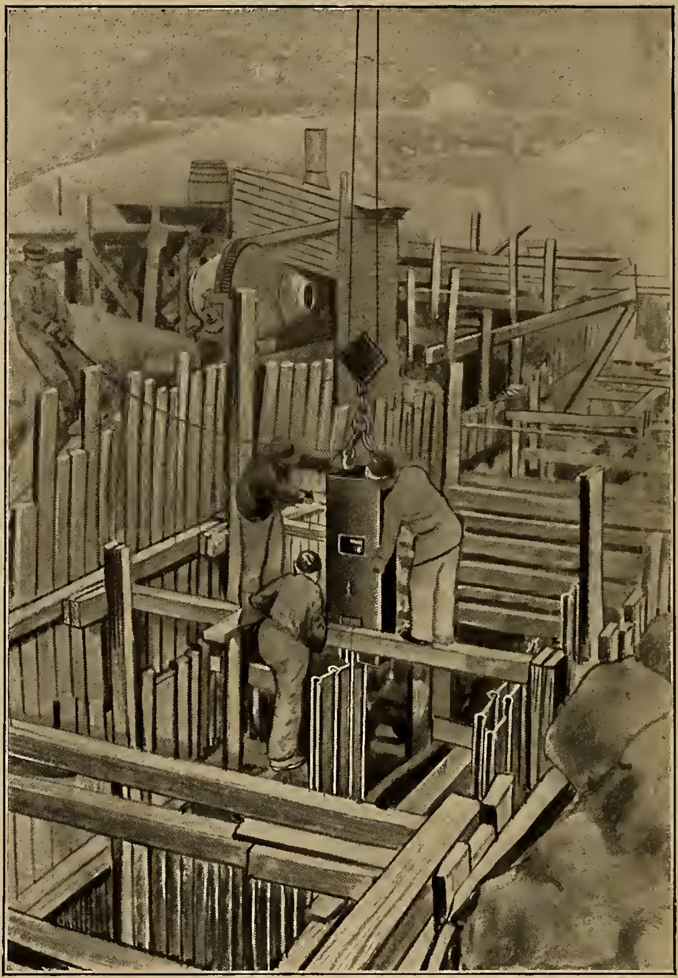
The Triumph Electric Company, Cincinnati, Ohio, have just issued a polyphase induction motor chart giving directions for testing such motors. A copy can be obtained by addressing them.

Personal

Lucuis I. Wightman, for the past six years advertising manager for the Ingersoll-Rand Company, 11 Broadway, New York, has resigned his position, the resignation taking effect August 1. He will open an office in New York City as an independent specialist in machinery advertising, handling the accounts of manufacturers of machinery and engineering products.

Mr. Wightman brings to his new enterprise qualifications peculiarly fitting him for this line of work. To his long experience in managing one of the largest advertising accounts and publicity departments in the machinery field, he joins a prior experience of years in practical mechanical and electrical engineering, construction work, machine design and manufacture, and machinery selling.

He is a graduate engineer, the author of a text-book on compressed air, and one of the authorities on compressed air subjects. His broad acquaintance in the world of trade and technical journalism, his understanding of advertising mediums and methods, and his intimate knowledge of engineering in many phases, will prove invaluable to those whose advertising accounts are placed in his charge.



THE ARNOTT PILE HAMMER DRIVING STEEL SHEET PILING FOR COFFERDAM CONSTRUCTION. UNION IRON WORKS, ERIE SIDING, HOBOKEN, N. J.

The Arnott Pile Hammer

THE increasing use of steel sheet piling has led to a demand for a convenient, powerful and effective machine for driving the piles in the correct position under the difficult conditions which usually surround such work. This means that the satisfactory pile hammer for this service should be capable of delivering its blows with such rapidity as to produce what is practically a continuous effect, without giving the pile opportunity to stop and be seized by the grip of the surrounding earth.

These conditions are fully met by the Arnott pile hammer, made by the Union Iron Works, Erie Siding, Hoboken, N. J., and the illustration above shows very clearly how a powerful pile hammer may be swung from the boom of a derrick directly over a cofferdam and drive the interlocking steel sheeting steadily and rapidly in the precise position required at the moment. Catalogue No. 2, to be had by writing to the Union Iron Works, at Erie Siding, Hoboken, N. J., tells of its many successful applications.

THE LATEST CATALOGUES

In writing for Catalogues please mention "Cassier's Magazine."

Cassier's Magazine invites manufacturers and others to send it their catalogues as issued, both for mention in this department and for the very complete library of catalogues which it maintains.

Steam Specialties

The Ohio Brass Company, Mansfield, Ohio. Catalogue H, devoted to the valves, fittings and regulators made by the Ohio Brass Company, and containing much useful information relating to the high-grade fittings of the manufacturers. These include radiator valves, valves for steam and for hot water, union elbows, globe, angle and check valves, bronze fittings of all kinds, and the Ohio pressure regulating valve for maintaining automatically a uniform pressure of air or steam from a higher varying pressure. This catalogue is an admirable example of the art of the printer and the engraver, and will form an acceptable addition to the collection of the engineer who desires to be informed upon the latest types of high-class fittings.

Wire Rope and Fittings

The Trenton Iron Company, Trenton, N. J. This well-known firm has just issued a small and convenient size catalogue of the wire rope and fittings manufactured by them. This catalogue is a good example of concise yet clear description of this line of product, and presents a vast amount of useful information, with many illustrations.

Particular attention is called to their patent locked wire cable, which, due to its construction, affords great durability and saves much wear of the carriage wheels. Other products of this company are described, while the final chapter is devoted to a brief description of the Bleichert system of aerial tramways. The latter, however, being more fully taken up in a separate publication issued by them, will prove of great interest to anyone who has to do with the rapid and economical transportation of materials.

Lifting Magnets

Cutler-Hammer Clutch Company, Milwaukee, Wis. "One Man and a Magnet" is the title of an illustrated leaflet which this firm has recently issued. It shows, by a series of illustrations, what one man (the crane operator) and the lifting magnet can do. A cross-section of their lifting magnet, with full description of its parts, is also given.

Pulverizers and Crushers

The Jeffrey Manufacturing Company, Columbus, Ohio. Catalogue No. 31 C, fully illustrated, just issued by this company, gives an exceedingly clear yet brief description of the crushing and pulverizing machinery for which this firm is so well known. Special attention is called to the Jeffrey swing hammer pulverizer, so designed that a uniform product can be maintained. This company claims for this new type of machine great reliability, large capacity, a uniform, fine product, greatly reduced consumption in horse-power per ton, and exceedingly low upkeep cost. Many other styles of pulverizers and crushers are illustrated and treated, and the book will be found of great interest.

Mechanical Calculators

The Felt & Tarrant Manufacturing Company, Chicago, Ill. Attractive and instructive booklet describing the successful adding machines manufactured by this firm, which will prove of interest and value to all those engaged in or responsible for accounting work. It contains detailed information of various lines of business for which their comptometer is adapted, with many flattering letters from large concerns using their machines.

Handling Power

WHEN a layman is handed a stick of dynamite or a cartridge of nitro-glycerine, he looks at it with something akin to awe, because he realizes that it contains latent energy which, if released, is capable of working death and destruction, or, if controlled, is able to perform feats of power otherwise impossible to unaided human effort. The same individual looks upon a lump of coal as a mass of inert matter, and rarely realizes that it, too, contains stored energy capable of performing labour of the highest value.

As a matter of fact, the coal contains energy of more value than the dynamite, because it can be handled with freedom and used with greater efficiency, since the power which it contains, stored within its mass from the time the vegetation from which it was produced absorbed the energy of the rays of the sun, can be released gradually and continuously, and thus is available under control, and not limited to the uncontrollable and explosive form.

Coal is thus interesting not only because it represents the stored energy of the sun in a by-gone age, but also because this energy is tractable, so to speak, and capable not only of utilization when and where required, but also safe to be handled and conveyed to points where it may be stored until required for conversion into immediate service.

The fact that the stored power in coal is capable of being handled and stored conveniently has resulted in the development of machinery for relieving human effort of the work formerly considered necessary in this department of industry, and this has doubtless been one of the important factors in the development of the modern power house. The centralization of power generation into a limited number of high-capacity stations means the concentration not only of power, but also of the material from which power is generated, of the fuel which must be brought to the spot by land or by water and then raised to the storage bins and held awaiting consumption. It must also be delivered from storage to furnaces as required, and thus held, controlled and delivered in a manner practically impossible with any other form of stored energy.

If coal consisted wholly of combustible material, of carbon and volatile matter, the delivery of the solid fuel would constitute the entire undertaking, so far as maintenance of continuous working is concerned. There is, however, always a non-combustible residue, forming the ash, and varying in quantity according to the character of the fuel itself, and provision must be made for the removal of this as it accumulates.

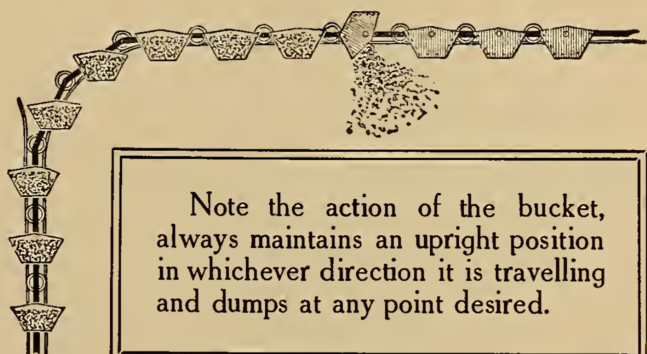
In the modern power plant the mechanical arrangement for the delivery of the coal usually takes the form of a continuous conveyor, taking the material from barge or train and delivering it into the storage bins without noise or fuss, where it awaits further delivery by gravity to the furnaces. A similar system keeps the ash-pits clear of ashes and delivers the non-combustible portion of the coal to the waste dump, car, or barge, and thus there is maintained a circulation not unlike that which goes on in the human body in its operations of nutrition, digestion and circulation.

It is, therefore, possible to handle power in its latent state with perfect ease, smoothness and efficiency, the actual energy remaining stored up until it is desired to release it and direct it to the use and convenience of man, and the mechanism by which this is effected forms one of the most important elements in the transformation of manual labour into the far higher phase of supervision and direction.

The same principles which have been so successfully applied to the handling of coal naturally adapt themselves to other materials, so that the scope of the system is widely extended.

"Hunt"
Noiseless Bucket Conveyor

For handling dry materials or liquids



Note the action of the bucket, always maintains an upright position in whichever direction it is travelling and dumps at any point desired.

Noiseless in operation

Costs less for maintenance power and operation than any other Conveyor

Conveyor over Coal Storage Bins
Morgan & Wright Co., Detroit, Mich.

Handles
Coal
Ashes
Ore
Phosphates
Sand
Gravel
etc.

Hoisting Towers
Cable Railways
Automatic Railways
Steam Shovels
"Industrial" Railways
Electric Storage Battery Locomotives

C. W. HUNT COMPANY

Established 1872

No. 45 BROADWAY
NEW YORK

Works: West New Brighton, S. I.
NEW YORK

The Utilization of Friction

NEARLY every inventor who has dabbled with the fascinating problem of perpetual motion ultimately comes to the conclusion that if it were not for the stubborn opposition of friction he would be able to solve the question successfully. He does not realize that if there were no such thing as friction we should be far worse off than we now are in all matters mechanical, and that we should lose far more than we could possibly gain if friction were abolished.

Without friction we could hold nothing in our hands, our buildings would fall apart, all bolted fastenings would become useless, railway transport would be impossible, and, once started, nothing could be stopped except by absolute blockade and consequent collision. These are but a few of the disastrous consequences which would follow the abolition of friction.

Let us now examine some of the advantageous applications of frictional resistance which have been utilized by the engineer. Apart from the great application of friction in the driving of railway trains upon their rails, of the operation of automobiles upon the highways, or even of the hauling of wagons by animals upon the roads, we see the usefulness of friction in many methods for the transmission of power. Every belt depends upon friction to give it the grip upon its pulleys which enables it to make the wheels go 'round, and the whole subject of belt-transmission includes a critical study of the friction possible between the leather of the belt and the iron or wooden surface of the pulley, and the same is true of the rope drive.

In driving individual machines from line shafting one of the oldest methods is the use of the leather belt, running over fast and loose pulleys; and it has been said that one of the best friction clutches in use is this simple device, by which the shifting of the belt from the fast to the loose pulley suffices to throw the power out of action and bring the machine to a standstill. This primitive device has its limitations, however, and when larger powers have to be handled something more substantial must be employed.

Especially when heavy machinery, offering great and stubborn resistance, has to be driven must some powerful and effective device be introduced between the motor and the machine, to enable shocks to be avoided and the effort to be applied gradually until the inertia has been overcome and the moving parts positively connected. Thus, in rolling mills, cement mills, rubber mills, mining machinery, bolt works, and similar situations, it is necessary to start the power and throw in the machinery gradually, until positive connection has been established. For such service some form of clutch mechanism is absolutely essential; a mechanism which can be thrown into gear gradually, permitting a suitable degree of slippage until the motion begins to be transmitted, and allowing the grip to be tightened until the hold is secured to an extent which enables the entire power to be passed on to the point where it does its useful work.

Uncoupling the work of the successful clutch is as important as making the connection. The power should not be thrown off suddenly, lest the relief upon the motor, of whatever kind, be followed by all the injurious effects of a runaway. With the properly constructed clutch, the release is effected as gradually as the original connection was made; the tool is stopped slowly and the resistance upon the motive power is gradually relieved, all destructive shocks being avoided and maximum efficiency obtained.

There is probably no more effective illustration of the scientific utilization of friction than appears in the well-designed friction clutch, a device which forms an essential element in modern machinery of transmission.

The Question of Handling]

PRACTICALLY all methods of determining the cost of manufactured products divide the matter into the cost of material and the cost of labour. Of these, the first element need not be here considered, since it must be ascertained in relation to the facts connected with its purchase, dependent upon market and local conditions. The second element, the labour cost of a product, is largely dependent upon time, and is usually made up of the wage rate and the time expended in performing the work. Even when some of the various wage systems based upon actual performance may be employed, these usually have their original rates based upon time studies, so that the importance of the time element in manufacturing cost is almost preponderant. The subject of overhead cost, including general expense, and all the various details which cannot be charged directly to the individual job, when analyzed to the ultimate elements, will be found to depend principally upon time, while the vital question of the machine-tool rate is also mainly based upon time.

Under such circumstances anything which reduces the time expended upon a piece of work must have a most important influence upon the actual cost of the product, and it is now generally understood that time-saving appliances hold a leading position in modern machine-shop economics.

If this is true in connection with original manufacturing, it is even more important in its relation to certain kinds of repair work. Thus, in railroad repair shops the principal item of importance to be considered in work upon locomotives, cars, or other equipment is not the actual cost of the work done in the shop, but the loss which is accruing because the engine or car is out of service and its earning power is being lost. During busy seasons especially, when the tonnage is heaviest and there is often a shortage of locomotives and cars, the daily loss incurred by delay in the repair shop far outweighs the actual cost of the work which is being performed, and thus every minute which can be saved becomes doubly valuable.

Formerly there was more time expended in handling the pieces than was used in actual machining operations, especially with heavy pieces of work. The hauling of the work to the tool, the placing it in position, and the removal after the planing, turning or boring was finished, took more time than the removal of the metal by the cutting tool. Apart from the time of the labouring gang by which this handling was performed, there remained to be charged the idle time of the machine tool and its operator, so that the efficiency of the handling portion of the job was necessarily very moderate under the old conditions.

With the advent of modern handling appliances, such as traveling cranes, industrial railways, and especially of highly efficient chain hoists and overhead tramrail, the question of time in handling work has been reduced to a minimum and the labour and expense costs proportionally lowered. When one man can pick up any load up to 20 tons, or two men with a modern high-efficiency hoist can do the work of an entire gang of labourers in a fraction of the time, it is evident that the solution of a controlling portion of labour cost has been found.

The ease with which the chain hoist can be installed, as compared with the erection of the more highly organized traveling crane, renders the use of such appliances broadly general; the overhead tramrail and trolley, or, when necessary, the simple hand traveler, provides all that is necessary for most work, so far as transport from point to point is concerned, while the powerful and highly efficient Triplex block enables the lifting of the burden to be accomplished with ease, certainty, and above all, with promptness.

Core-Drill Economics

IN considering schemes and operations having to do with the material constituents of the earth's integument, perhaps nothing can be more suggestive and helpful to have at hand than an 8-inch terrestrial globe. It offers special facilities for us if we wish to do our thinking to scale, which is really more necessary than drawing or working to scale, as correct thinking must precede successful and profitable accomplishment.

On this 8-inch globe, 1 inch in any direction will represent very closely a thousand miles; and one-thousandth of an inch, or, say, one layer of the thinnest tissue paper, therefore, will represent one mile, covering practically our utmost penetration and knowledge of the earth's crust. The deepest coal mine in the world is not more than three-quarters of a mile down, and none in the United States has reached half through our sheet of tissue paper. This may help us to realize how infinitesimal are our most boasted operations, in comparison with the bulk of the body whose skin we have so imperfectly scratched, and it suggests how saving we should be of our efforts that none of our time or strength should be wasted.

The most valuable of all devices as yet in sight for the revelation of Nature's cunningly hidden treasures is undoubtedly the core drill.

It is of unspeakable value to the miner and prospector in locating veins and revealing deposits previously unknown. Not the least of its value lies in the determination of where not to sink shafts or run tunnels, thus saving unnecessary labour.

An obvious suggestion in connection with the work of the core drill is that its own results should be systematically recorded and kept available for future consultation, so that other prospectors in the same neighborhood or investigators of the same strata should have the benefit of the preceding labour without being obliged to do the work over again. It would seem to be an open question whether the records of the core drill, however and by whom made, should be regarded as the exclusive property of those with whom they have been originated, or whether they are not subject to the general claim of the mass of humanity which is beginning to crowd the earth and must live by what can be drawn out of it.

The systematic arrangement and preservation of such core samples or records would seem to be one important service which could, and should, be rendered by the new Bureau of Mines. We should never be satisfied for this important bureau to be merely an accumulation of records after the event. It should be able also to indicate some, at least, of the opportunities of the future, and thus promote more gainful practice in working beneath the surface of the earth, just as the Department of Agriculture is doing much to make farms more remunerative. Immense sums have been and are being most commendably spent by the government in mapping the surface of the land, and, to some extent, in determining its elevations and depressions. Expenditures for this purpose must not only be regarded as legitimate, but would be insisted on by popular opinion, if any attempt were made to curtail them. Why should we not also advocate the mapping of the earth below the surface within practically accessible depths? We can only imagine what would be the result if the Bureau of Mines had a thousand core drills continually at work, intelligently located and directed, and could thus be able to furnish accurate tabulated information for the benefit of future development and work.

Reinforced Concrete

IT is rather interesting to consider that, although man has long known himself to be composed of a skeleton clothed with flesh, he has but recently adopted the idea of placing a skeleton within the structure of his buildings. Studies of masonry structures considered the crushing resistance of the stone, brick or concrete employed as the sole material, and emphasized the fact that under no circumstances was any portion of the fabric to be subjected to tension stresses.

When, however, the idea tardily came to the fore that tension stresses might easily be met by the introduction of members of proper material in the proper place, there was produced a new system of construction, given at first a variety of names, but finally accepted under the generic title of "reinforced concrete."

The discovery that beams, columns, floors, walls of concrete, could be given remarkable and unusual strength merely by imbedding in the mass certain rods, bars or shapes of steel, was followed by a rush of so-called "systems," some good, some indifferent and some utterly worthless. Builders with little or no knowledge of the nature, extent or distribution of stresses produced structures in which the use of imbedded steel utterly failed to produce the strengthening effects, and some disastrous failures reflected seriously upon the whole art of reinforced concrete construction. On the contrary, able engineers in the United States and in Europe designed works in which the various compression and tensile stresses were properly met by corresponding elements of concrete and of steel in such a manner as to insure a maximum of strength with a minimum expenditure of material.

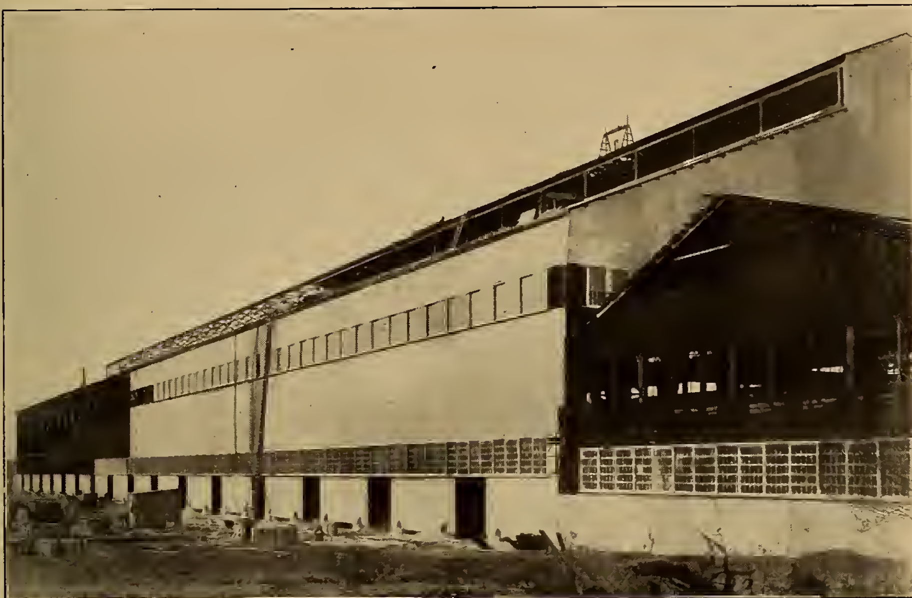
There has thus been developed a new department in the science of construction, one of which the laws are well known and in which the methods are becoming standardized. This is true not only for structures which must be planned especially to meet particular requirements, but also in the production of what may be termed the "elements" of building construction.

In the early days of timber structures the properties of timber posts, beams and surfaces were well known and widely adapted. When cast iron first entered the field it was mainly in the form of pillars, to support interior crushing loads, although cast-iron beams, proportioned with heavy lower flanges to resist tension, or trussed with wrought-iron rods, were sometimes employed. Modern steel structures are the result of a natural evolution from these earlier types, and contain columns, beams, struts and braces, all of standard shapes, manufactured in quantity and built up from selected stock.

Following out the analogy, the use of reinforced concrete is being developed along similar lines. Concrete piles are manufactured in quantity and sunk to form foundations of strength and efficiency. Columns, reinforced to resist deformation, sustain loads far greater than would be possible for plain concrete, while beams of almost any required span are scientifically designed with reinforcement along the lines of tensile stresses.

There has thus been a marked advance over the early days, when the idea that any sort of reinforcement would do was prevalent. The laws of evolution work out their result in the world of applied science as they do in the animal kingdom, and the fittest gradually survives.

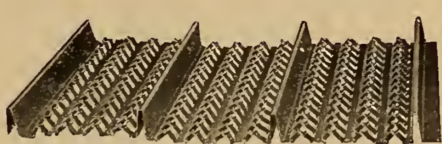
By the use of properly designed elements, therefore, all the uncertainties which attended the early experiences with reinforced concrete have been removed and the combined materials placed in the category of standard structural details, thus forming one of the widest extensions of the scope of scientific building which has been effected since in commercial introduction of iron and steel for purposes of construction.



HY-RIB ROOFS AND SIDING

To make your factory or warehouse permanent and fireproof at very little cost, use HY-RIB plastered with cement for roofs and siding. Saves insurance, repairs and painting. Much more economical than short-lived, leaky corrugated iron or quick-burning wood sheathing.

Used in hundreds of buildings for Roofs, Siding, Floors, Ceilings, Firring, etc.



Hy-Rib is a steel sheathing stiffened by deep ribs made from the same sheet of steel. **Does away with centering in floors and roofs, and with studs in walls and partitions.**

Merely set the Hy-Rib sheets in place, apply the cement mortar, and the slab is complete. So simple that your own men or local builders can erect it.

Before you build, write us for complete information and **free Hy-Rib Catalog.**

Hy-Rib is one of the products of the Kahn System of Reinforced Concrete —used in over 4,000 important buildings.

KAHN SYSTEM
Reinforced Concrete

TRUSSED CONCRETE STEEL CO.

546 Trussed Concrete Building, Detroit, Mich

Aerial Tramways

WHEN Oliver Evans remarked that the time was not far distant when a man would be able to breakfast in New York, dine in Philadelphia and sup in Washington in the same day, many persons thought he was crazy. If he had ventured to hint of a railway through the air, he would surely have been considered by all as a candidate for the lunatic asylum. Not only have such things come to pass, but an aerial tramway is no longer looked upon as a novelty. On the contrary, such lines are now recognized as well established means of conveyance, not only in mountainous and other localities where a surface railway could be built only at great expense over a circuitous route, but even over comparatively level ground. Even when the ground is not uneven, the cost of an aerial tramway will compare favorably with that of a surface railway, especially when it is considered that the cost of re-handling the material at either end of the line on the surface railway will often exceed the entire cost of operating the overhead line; owing to the fact that the cars on a surface track cannot always be brought close to the points of loading and discharge.

There is a common impression, however, that such lines are of limited capacity, this idea being due to the fact that the first aerial tramways were of the single-rope type, in which one rope served both as the support and the means of propulsion for the pendant carriers, an arrangement adapted to carry only comparatively light loads. The Bleichert type of aerial tramways, however, uses separate track cables of the locked-coil construction for the support of the carriers and employs a light endless traction rope for their movement, this arrangement enabling much heavier loads to be carried, sometimes exceeding a ton, so that any engineer may now undertake to construct such a line to carry up to two hundred tons an hour, if desired. "See nothing in it," as Sir Charles Coldstream remarked, when he looked with disappointment into the crater of Vesuvius.

An example of the carrying capacity of a tramway of this kind is seen in the line built by Bleichert many years ago, for the Vivero Iron Ore Company in Spain, which has a capacity of 250 tons an hour.

A distinction should be made between the aerial tramway and the so-called wire-rope tramway in which cars moved over surface tracks by means of wire ropes. The term "aerial" very properly indicates the fact that the loads are transported above the surface through the air, thus enabling them to clear all surface irregularities, and rendering it unnecessary to bridge streams, clear away timber, or construct any roadway upon the ground.

The introduction of such aerial transport has been an important factor in the development of valuable natural resources which might otherwise have remained unavailable, owing to the difficulties of the situation. Many valuable mines are found in mountainous situations so difficult of access that the cost of railway construction and handling would render the cost of operation prohibitory. The use of the aerial tramway enables such deposits to be worked and the product to be delivered across ravines, torrents, etc., to a point where a track is available and thus enabled great additions to the wealth of the world to be made.

The steepest grades and the roughest ground may be overcome by the aerial tramway, and no point is too difficult to be reached and brought within the range of civilization, if the value of the material to be obtained warrants the cost. Thus the engineer comes to the task of the exploitation of the natural resources of those parts of the world yet awaiting development and extends the scope of industries to points formerly considered inaccessible, except to the explorer and savage.

Manufacturing News

The New Monarch Pile Hammer

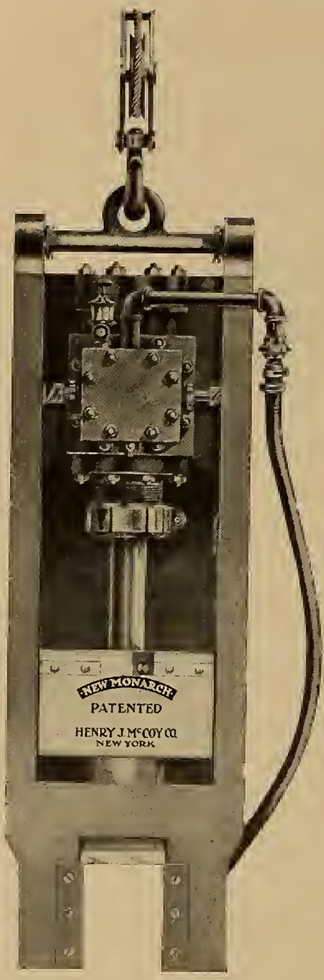
THE extending use of piling of all kinds, including timber, concrete and sheet steel, has led to the development of a pile driving hammer which will enable the work of driving all such piling in a manner to be performed with the modern efficiency demanded of engineering operations.

The older method of driving piles was that of impact of a heavy weight raised slowly through a considerable height and allowed to fall on the head of the pile. This plan was both slow and imperfect, much of the force of the blow being expended in crushing the head of the pile, or in brooming out the lower end against the soil. The especial defect in this system, apart from its slowness, lay in the fact that the movement of the pile came to a stop between the blows, so that the entire resistance with which the earth gripped the sides of the pile had to be overcome by each blow. It is well known that the friction of rest is much greater than the friction of motion, and this fact doubtless has much to do with the inefficiency of the older form of pile driver.

The general introduction of steam or compressed air in building operations has led to the development of the steam pile hammer, of which the New Monarch, built by Messrs. Henry J. McCoy Company, is a leading example. This form of machine depends for its efficiency upon the rapidity of the blows given by a hammer of moderate weight, the blows following each other so closely that the pile has not time to come to a standstill before the blow is repeated. The effect of this action is to provide what is practically a continuous movement. Instead of a few blows a minute the New Monarch gives 200 blows per minute, the stroke being but eight inches instead of several feet, the rapid, short blow taking the place of the slow blow.

In addition to the force of gravity the New Monarch hammer utilizes the force of the steam or compressed air upon the top of the piston, and the valve movement being automatic, no especial attention is required from the operator beyond the general direction of the machine to its work.

The hammer is wholly self-contained, and may be used either in fixed leaders, when such are convenient, or may be suspended from the boom of a derrick or crane, and thus employed to drive sheet piling, for example, beyond the reach of solid support in



THE NEW MONARCH PILE HAMMER

the construction of coffer-dams, dock walls, and the like.

The steam pile hammer has thus become an essential part of the equipment of the modern contractor, and its use has done much to aid in the successful applications of modern sheet piling and in the construction of foundations for tall buildings, wharves and bridges.

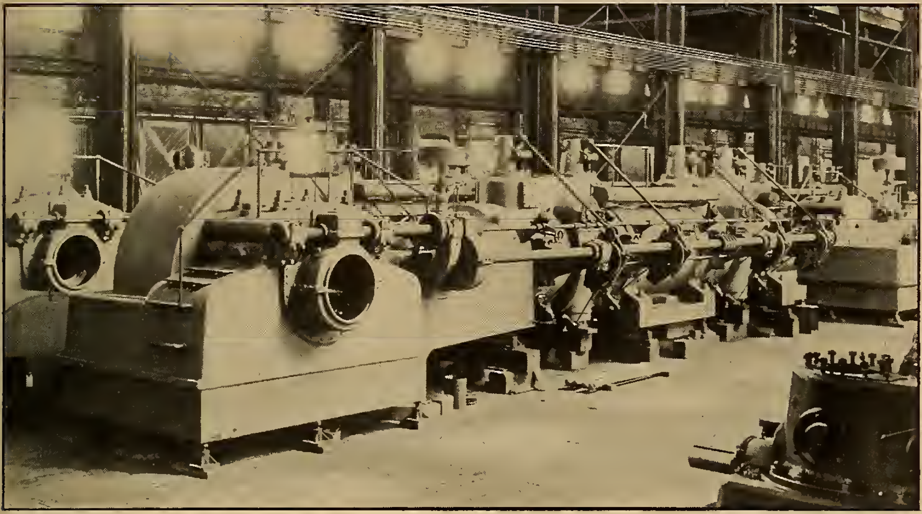
The construction and numerous applications of the New Monarch steam pile hammer are fully set forth in the catalogue of the Henry J. McCoy Company, to be obtained from the manufacturers, at 65 Dey street, New York City.

Large Gas Engines

We have referred repeatedly in these pages to the development of the large gas engine, especially in connection with the direct utilization of the waste gases from blast furnaces for fuel. Probably some of the most important work which has been done along this line is due to the efforts of the Allis-Chalmers Company, and the engines at Gary and elsewhere are examples of the extent to which the large engine, using blast-furnace gas, has been applied to iron and steel works for furnishing blast and for the generation of power. We now illustrate some portions of a notable installation by the same company. During the past few months Allis-Chalmers Company has shipped four gas engine generating sets and two gas engine blowing units to the Lake Superior Iron and Steel Corporation at Sault Ste. Marie, Canada, and has two more of the blowing units nearing completion. Each one of these units required twelve cars for its transportation and its weight approximated 1,000,000 pounds.

These gas engine units are being installed in a large extension of the Lake Superior Iron and Steel Corporation's plant at Sault Ste. Marie, Ontario, Canada. The original rail mill will have a largely increased capacity and new plate and merchant mills will be built, as well as coke ovens. Operations will be started at the plant in the near future. For furnishing power for the mills and blowing the furnaces the company purchased the above units from Allis-Chalmers Company. They will be supplied with gas from the blast furnaces.

The gas engines are all alike, being of the twin tandem, four-cycle type, with cylinders 34 x 48 inches. They conform to the company's standard in all respects. Four of these engines are direct connected to 1,765 K. V. A., 25 cycle, 3 phase, 2,300 volt alternators running at 107 revolutions per minute. These sets will supply power

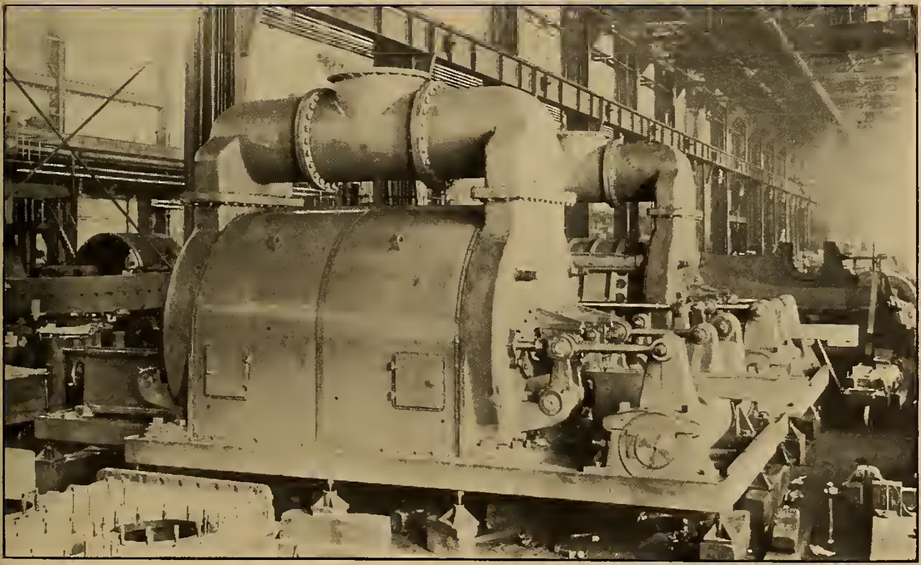


ALLIS-CHALMERS GAS-POWER BLOWING ENGINES

for driving the motors about the mill.

The other four units are to be connected to the new Slick blowing tubs manufactured by Allis-Chalmers Company. These tubs are 64 x 48 inches, and are arranged to operate duplex on the opposite side of the main shaft from the engine. Each blowing unit has a capacity of 25,000 cubic feet per minute when running at 72 revolutions per minute, but can be speeded up to 85 revolutions per minute if necessary.

When the new works are completed this will be the largest steel-producing plant in Canada, and naturally the most modern. Mr. Alfred Ernst has been consulting engineer on the work, and much of its success will be due to his efforts.



SLICK BLOWING TUBS, ALLIS-CHALMERS COMPANY, MILWAUKEE

Record Sale of Rambler Automobiles

FOUR hundred Rambler cars were sold by the P. J. Downes Company, of Minneapolis, to farmers in the States of Minnesota and the Dakotas during the first six months of 1910. The average price per car was $2,250.

Because the sales of Ramblers in the cities have been exceptionally large and the average price is above two thousand dollars, this record sale in the agricultural districts is considered remarkable. It demonstrates that farmers are buying cars of better quality and are not confining themselves to those of low value.

By way of comparison, the Thomas B. Jeffrey Company have furnished information indicating that this record sale in Minnesota and the Dakotas compares most favorably with sales of Ramblers in the larger cities.

THE Fidelity and Casualty Company of New York has issued sets of rules for operating high-pressure power boilers and for operating low-pressure steam and hot water boilers, which should do much to aid in the prevention of accidents and disasters to apparatus in these important classes. No matter how skilled the attendant may be, it is most desirable that he should have before him rules which have been prepared by able engineers for the especial purpose of aiding him, not only to manage his equipment to the best advantage, but also to advise him of the best methods of dealing with those emergencies which are liable to occur even with the most careful attendance.

For owners the observance of these rules is doubly important, since they have been drawn up with the object not only of promoting safety, but also for the purpose of increasing durability and prolonging the life of the boilers, as well as reducing the extent and cost of repairs.

Copies of these rules should be posted in every boiler room, and they may be obtained on application to the company, at 982 Liberty street, New York. The Fidelity and Casualty Company is also prepared to give, through its inspectors, such special instructions which may be needed to cover matters not included in the printed rules.

The Southern California Edison Company has announced the selection of a site at Long Beach, California, upon which will be constructed a steam-power electric generating plant, which will ultimately be one of the largest in the United States.

In describing the proposed plant, Mr. W. A. Brackenridge, vice-president and general manager of the Southern California Edison Company, says: "The first building will be of sufficient size to contain two turbo generating units with a total output capacity of 40,000 horse-power of electric energy.

"The building will be so arranged that it may be added to from time to time as requirements for additional power may demand.

"The dimensions of the first building will be 300 ft. by 80 ft., and 90 ft. high. There will also be a transformer and switch room 80 ft. by 50 ft.

"Contracts have been let for a part of the machinery and boilers. These are substantially all of the plans that have been definitely decided upon.

"It is expected that the machinery now under contract will be installed and ready for operation about the first of the coming year."

The Gunnison Valley Power Company, Gunnison, Utah, is developing its water-power site, and has recently placed an order with Allis-Chalmers Company for the necessary equipment. This will include a 540 horse-power single horizontal turbine, with cast iron spiral case operating under a head of 210 feet, direct connected to a 300 K. V. A., 2,300 volt, 60-cycle, 3-phase, 450 r.p.m. alternator. A 10 kilowatt exciter will be direct connected to an extension of the main shaft. Three 100 K. V. A. oil-filled, self-cooled transformers will be used

to step up the voltage for transmission.

Arrangements have been made by the C. W. Hunt Company, New York, builders of coal handling, conveying and hoisting machinery, by which their business on the Pacific Coast will be handled by the San Francisco Bridge Company, with offices at 865 Monadnock Building, San Francisco. The company has just completed a naval coaling station in San Francisco Bay for the Government.

The Jeffrey Manufacturing Company, main office and works, Columbus, Ohio, are changing the location of their Denver office from 1711 Tremont place, and after August 1 will occupy a commodious suite of rooms in the First National Bank Building.

This company, besides maintaining a large selling force in over a dozen of the leading cities of this country, also maintain a corps of engineers at their branch offices, situated in the following cities: Chicago, St. Louis, Denver, Montreal, Pittsburg, Charleston, W. Va., Boston, New York, and Birmingham.

There are also nearly 100 Jeffrey agencies in additional cities in this country and abroad.

One of the largest single sales of transformers made by Allis-Chalmers Company during the month was to the Delaware, Lackawanna & Western Railroad Company. The order includes six 200 kilowatt, 3 phase; three 200 kilowatt, single phase; two 150 kilowatt, 3 phase, and one 100 kilowatt, single-phase, oil-filled, self-cooled transformers. These will be installed in colleries and washeries at Scranton, Nanticoke and Taylor, Pa.

New Dodge Warehouse Building

IT will not be long until the Dodge Manufacturing Company will be storing pulleys, hangers, clutches, bearings and other stock goods in its new warehouse at Mishawaka.

Work is progressing with the speed of a Twentieth Century flyer. Already the first floor has been passed and material is being laid for the second. As concrete is mixed by machinery and conveyed as needed by means of bucket elevators and pipes, no time is lost in keeping things moving every working minute in the day.

The completed structure will be one of the most modern in the country. Reinforced concrete is being used entirely with "Fenestra" steel windows, thus insuring proof against fire. The plans call for four stories and a basement, the length being 256 feet and the width 112 feet.

Besides its use as a place for storage, excellent facilities will be provided for the crating of goods in double quick time. Along one side and one end a loading platform has been built where cars can be filled without delay and hurried to the Lake Shore & Michigan Southern Railroad by ample trackage for immediate delivery to customers.

The Dixon Crucible Company at their annual stockholders' meeting unanimously re-elected the old board of directors, and the board of directors re-elected all the former officers. An expression of thorough satisfaction with the management of the company by its officers was made by the large representation of stockholders present.

The Page-Storms Drop Forge Company, of Chicopee, Mass., has installed a Westinghouse type J-60 gas-producer plant for generating fuel gas from buckwheat anthracite for a Welbe gas engine formerly supplied by two producers of the same make. The suction producer represents the standard design of the Westinghouse Machine Company, East Pittsburg, Pa. The plant of the Page-Storms Drop Forge Company furnishes 60-cycle alternating current for local lighting and power operations. Mr. Lawrence Foy has been in charge of the erection of the new unit.

Polyphase Induction Motors

The wide field of application of the Polyphase Induction motor is due to the many advantages inherent in this type of motor. Prominent among these advantages are its simplicity, high efficiency and the small amount of attention which it requires. Other advantages are its ability to carry large overloads for considerable periods without serious overheating, entire absence of sparking enabling it to be used in powder mills and other places where direct current machines would be dangerous, and its quick and certain starting.

Bulletin No. 4751, recently issued by the General Electric Company, is devoted to various types of that company's induction motor. The bulletin contains illustrations and descriptions of the design and construction of the skeleton frame motor of different sizes, and describes a vertical motor which can be furnished when this form is advantageous.

This company manufactures a full line of mill type induction motors known as type XI. These motors are specially adapted for such exacting service as is encountered in steel mill operation.

The General Electric induction motors can be constructed for more than one speed if desired, are made for various frequencies and voltages and for two and three phase circuits. The bulletin contains illustrations of starting devices for use with these motors, and also of various parts composing the motor.

The Precision Instrument Company

THERE has been organized at Detroit a concern under the name of the Precision Instrument Company to manufacture and sell the various instruments now made in England by the firm of Alexander Wright & Co., these including the Simmance and Abaday automatic combustion recorder for the continuous determination of the percentage of carbon dioxide in chimney gases from boiler furnaces, as well as the other devices of the same firm for recording the flow of steam, gas, water, air, or other fluids.

Alexander Wright & Co. was founded in 1843 by Alexander Wright, and has developed a line of 800 instruments. Mr. Wright was the inventor of the disc type of recording chart popular in this country. Mr. Abaday is the author of a voluminous work on the analysis of gas well known on this side, and he and John F. Simmance, the other active director of Wright & Co., have made many contributions to science in the form of technical papers and lectures. Mr. Abaday is a member of the Westminster City Council, and is chairman of the Council committee on works.

The Detroit company has the exclusive license for the United States and Canada.

Further information concerning the plans of the American company may be obtained by communicating with the Precision Instrument Company, 49 Larned street, West, Detroit, Mich.

The Conquest of Lockjaw

THE popular belief that a wound from treading on a rusty nail is very likely to cause tetanus is quite correct. This is not because it is a nail or is rusty, but because by lying on the ground it has become infected with the germs of lockjaw. Moreover, as the punctured wound caused by the nail bleeds but little and this blood dries up and excludes the air, the most favorable conditions for the development of tetanus exist; for, as Kitasato, the Japanese bacteriologist, proved, the absence of oxygen is most favorable to the growth of this germ.

The germ itself looks very much like a tack. So virulent is it that its toxin in doses of 1.200.000th of a teaspoonful will kill a mouse. It has been found by experiment that the poison is carried up to the spinal cord, not by the absorbents or the blood-vessels, as are other poisons,

but through the motor nerves themselves. Fortunately, an anti-poison or antidote has been developed, but so prompt is the action of the poison that in an animal, two minutes after the injection of a fatal dose of the poison, twice as much of the remedy is required as if it had been administered with the poison; after eight minutes ten times the amount, and after ninety minutes forty times the original amount is necessary. This antitoxin is entirely harmless.

As a result of antiseptic methods lockjaw is now almost unknown except after neglected wounds, instead of being terribly frequent as it formerly was. When it is feared, the antitoxin is used as a preventive, and when it has developed, as a cure.

In animals, for naturally horses suffer enormously more frequently than man, the same antitoxin is used. In 163 horses that had operations performed on them, but were protected by the antitoxin, not one developed tetanus, whereas of eight cases unprotected by the antitoxin, five developed tetanus. The result of all these experiments has been that what is known as Fourth-of-July tetanus has been enormously diminished, chiefly by the antitoxin used as a preventive.—*W. W. Keen, M.D., LL.D., in Harper's Magazine for July.*

The Federal Bureau of Mines

THE act establishing a Bureau of Mines in the Department of the Interior, approved May 16, 1910, became effective July 1. As originally approved, the law contemplated the transfer of the entire Technologic Branch of the United States Geological Survey, the mine accident investigations, fuel investigations, structural materials investigations, the entire personnel, property and equipment to the Bureau of Mines, but the Sundry Civil Appropriation act, approved June 25, amended the law to such an extent that the structural materials investigations, including the personnel and equipment for these investigations, went to the Bureau of Standards, Department of Commerce and Labor.

Carrying out the spirit and intent of the law so amended, the Secretary of the Interior has transferred to the Bureau of Mines the investigation of mine accidents and fuels, together with the personnel and equipment of these investigations, and has transferred to the Bureau of Standards the structural materials investigations and the employees of the Technologic Branch of the Survey engaged in these investigations. The fully equipped testing station at Pittsburg also goes to the Bureau of Mines.

The Bureau of Mines therefore includes the mine accidents and fuel investigations, for which an appropriation of $410,000 was made by Congress. The total appropriations for the bureau, including salaries, rent and expenses of removal, amount to $502,200.

The work of the Bureau of Mines for the first year will be a continuation and expansion of the work carried on by the Technologic Branch of the Geological Survey. The law in itself provides for a variety of other problems that properly belong to the Bureau of Mines, and which should eventually be undertaken, such as methods of mining and metallurgical processes, but these activities will be deferred for the most part until Congress gives additional authorization in the shape of adequate appropriations. The spirit of the debates in Congress both on the Bureau of Mines legislation and on the appropriation items emphasized the desire to regard the mine accident investigations as urgent and this will be the feature of the work.

In all, $310,000 was appropriated for mine accident investigations. Of this sum under the general plans approved by the Secretary of the Interior, $120,000 is to be spent on the rescue stations, $36,000 for housing nine stations, $34,000 for equipping eight new stations, and $10,000 for additional equipment for five existing

stations. The allotment for the investigation of explosives is $40,000; for electricity in mining, $14,000; appliances for preventing mine accidents, $8,000; examination and codification of mining laws, $5,000, and other technologic investigations, ore treatment, etc., $10,000. For the analyzing and testing of the coals, lignites, ores and other mineral fuel substances belonging to or for the use of the United States, $100,000 was appropriated. Of this amount $35,000 will be spent in the chemical and physical investigation of fuels; $25,000 in the inspection of government fuel purchase; $22,000 in fuel efficiency investigations, $5,000 in lignite and peat investigations, and $4,000 in briquetting investigations.

The mine accident investigations, which have been transferred from the Geological Survey to the Bureau of Mines, were first authorized in the Legislative Appropriation act of May 22, 1908, carrying for this purpose an appropriation of $150,000. This was followed by a similar appropriation carried in the act for the sundry civil expenses of the government for 1910. A mine experiment station was established in Pittsburg during 1908, at which, since that time, investigations of explosives, coal gas, dust, electricity and other possible causes of mine explosions have been continually under way. The mining engineering field force of the Geological Survey has already made decided progress in the study of underground mining conditions and methods. Practically all of the coal mines in which mine explosions have occurred during the last two years have been carefully examined, the gases, coke and dust have been analyzed at the laboratory at Pittsburg and every effort has been made to determine the explosibility of various mixtures of gas and air in the presence of shots of different types of explosives. Considerable progress has also been made in the investigation of explosives used in coal mining, and the conditions under which they may be used with least risk. Manufacturers have submitted many explosives for test at the station, and a considerable portion of them passed and have been classified among the permissible explosives. The investigations and educational work in connection with the use of artificial breathing and other types of mine rescue equipment, the so-called oxygen helmets have not only been useful in developing a more satisfactory use of such equipment in the examination of mine explosions, but also better methods for using this equipment in mine rescue work.

The fuel investigations under the Geological Survey, and which are transferred to the Bureau of Mines, have already resulted in a better realization throughout the country as to the value of fuels. One result of this work is that nearly all of the fuel now purchased by the Federal Government is bought on specifications and subject to test by the fuel division, or purchased after examination made of the coal supplied by the mines from which coal is delivered to the government.

The publications of the survey relating to mine and fuel investigations, those prepared by the Technologic Branch, will in the future be distributed by the Bureau of Mines. The publications relating to structural materials will continue to be distributed by the Geological Survey. The last of the bulletins of the Technological Branch to be published by the survey will be issued from the Government Printing Office about August 1. This bulletin relates to the explosibility of coal dust, and was prepared by G. S. Rice, with chapters by J. C. Frazer, Axel Larsen, Frank Haas and Carl Scholz.

The first of the Bureau of Mines bulletins, the Volatile Matter of Coal, by H. C. Porter and F. K. Ovitz, will be published in the next few months. Then will follow Coal Analyses, by N. W. Lord and J. S. Burrows; Final Data Regarding Steam Tests, by L. P. Breckenridge; North Dakota Lignite as a Boiler Fuel, by D. T. Randall and Henry Kreisinger; Producer Gas Tests in 1905-1907, by

R. H. Fernald; The Coke Industry as Related to the Foundry, by Richard Moldenke; Coals for Illuminating Gas, by A. H. White and Perry Barker, and Petroleum for Combustion Under Steam Boilers, by I. C. Allen.

These publications when issued can be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

The Garbage Disposal Plant at Columbus, O.

ENGINEERS interested in the important question of municipal disposal of garbage will note with attention the inauguration of the plant at Columbus, Ohio, which includes in its details some important applications of mechanical appliances which have been used to advantage in other departments of work.

The plant has a capacity of 80 tons of garbage per day; at the outset only half of its capacity will be required, although it will gradually increase as the summer advances. Chief Engineer Osborn, in charge of this plant, advises that the entire equipment, including all the machinery, is working without a hitch, and it is generally considered by the city officials and out-of-town visitors, who have already inspected this plant, that it is the most modern and up-to-date garbage plant in the world.

The buildings were erected at a cost approximating $100,000. In addition to this, complete equipment approximated nearly $150,000, including elevating and conveying machinery, the latter being designed and built by the Jeffrey Manufacturing Company. The unique construction of this equipment will save the city thousands of dollars. The products, consisting of fertilizer, oil, etc., will be sold; the proceeds, it is thought, will pay for the cost of operating the plant.

Notwithstanding the enormous amount of material to be handled and the extensiveness of the operations of this plant, only twenty men will be required when the plant is running at its greatest capacity.

The city has also purchased a number of new garbage wagons, which will be put in service collecting the garbage and delivering it to a point on Mound street, at the canal. The Hocking Valley Railroad will convey it from that point to the new plant, which is located about 1½ miles south of the city limits.

Judicious Advertising

IN an interesting address delivered before the Associated Advertising Clubs at Omaha, Mr. R. R. Shuman calls attention to the value of trade and technical papers for advertising of general articles, and some of his remarks will be found worthy of thoughtful consideration.

After calling attention to the fact that only about 3.7 per cent. of the families in the United States have incomes between $3,000 and $6,000 per year and are in a position to buy high-class goods, such as automobiles, pianos, lands, investments, etc., he proceeds to discuss the advantages of trade and technical papers. These are of three general classes:

1.—Trade papers, subscribed for by a half million retail merchants and read studiously by them because of the practical information they contain—missionaries of commerce these, bringing the wholesale markets to the merchants' desk; the key to the whole problem of distribution through retail channels. Their readers are employers, and such of their subordinates as are empowered to select and buy the stocks that the merchant shall sell.

2.—Technical publications, engineering and scientific rather than commercial, subscribed for by the men who build and equip railroads, factories, office buildings—cities—by the captains of industry—and passed along with authoritative marginal notes to the heads of their departments. These papers are depended on for authentic information, on the wholesale markets for raw materials,

the development of new machinery and methods. They exert a vast power in both the administrative and mechanical development of a half million industries. They are read, not idly, for amusement, but earnestly, in the quiet of the private offices, and they are preserved for future reference. Here, too, we have employers for readers, together with their highest paid subordinates.

3.—The third general class—smaller one—is the shopman's paper—full of practical shop kinks—and read (as they never read their bibles) by superintendents, foremen, engineers and other well-paid heads of families.

These are general classifications only, as most trade papers combine in a measure all three elements.

The commercial and technical papers are ideal for selling automobiles, both pleasure and commercial, as well as such things as pianos, piano players, high-priced talking machines, bonds, investments, irrigated lands, fire and life insurance, travel tours and the long line of necessities and luxuries such as only the well-to-do can buy, and some day some live maker or seller of such things will "make a killing" by putting his advertising money into these mediums instead of the "hall room" favorites, read mainly by people who would like to own these things but can't.

The third class—the shopman's paper—gets behind doors that are locked to your salesman, reaching and converting the men who have the brains to specify, if they have not the money to buy, new equipment for shop and store.

All three classes offer an ideal audience, paid and trained to read (and to heed) every advertisement of every good thing, whether for their business or for their household and personal needs.

News Items

Mr. Sylvester S. Howell has become associated with Paul M. Chamberlain, engineer, Marquette Building, Chicago, under the firm name of Chamberlain & Howell. The firm will carry on the designing and consulting engineering practice established by Mr. Chamberlain. Mr. Howell's many friends will welcome this move as giving wider latitude for his talents and varied experience. Mr. Howell received his collegiate education at the Iowa State College, and since 1887 has given his attention to engineering.

The Bucyrus Company, of South Milwaukee, Wis., announces that it has acquired the exclusive rights to manufacture and sell the Heyworth-Newman drag-line excavators, and that it has taken over the business which has recently been conducted by James O. Heyworth, of Chicago.

These machines have been handling material in a manner which has attracted widespread attention. Three of them are at work on the North Shore drainage canal of the Chicago sanitary district, near Evanstown. Others are being used in various parts of the country, particularly on the New York State barge canal and the Cape Cod Canal. Various recent records show that the Heyworth-Newman bucket machines handle about double the quantity of material per month that is being handled by drag bucket machines of other makes.

The important feature of the Heyworth bucket is that it is designed with a rigid bail, which can be adjusted so that it actually digs the material instead of scraping off thin layers of it, as is the case with other buckets. The bucket is also of such shape that it clears itself in dumping, even when handling extremely sticky material. It is claimed that this machine can dig practically any material which a steam shovel can handle. It is believed that this excavator will meet successfully the demand for a machine which will economically dig canals, irrigation ditches, and do certain classes of railroad construction work.

For full information concerning this improved excavator, address The Bucyrus Company, Milwaukee, Wis.

THE LATEST CATALOGUES

Furnaces

W. S. Rockwell Company, New York, circular No. 11, devoted to t Rockwell Spring-Fitting Furnace, for heating and fitting springs, adapted for use with oil or gas burner, and so arranged that no blast or flame impinges directly upon the steel, giving uniform and reliable results. Data and dimensions of sizes are appended, with directions for ordering.

Rheostats

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis. Booklet describing the Battery Charging Rheostats for use in connection with the charging of ignition batteries and for general charging work. Full page illustrations are given of the various types, together with descriptions of protective panels and devices. A table of electrical data and list prices is given, and the publication should be of much interest to all who have to do with battery charging.

Good Roads

Barrett Manufacturing Company, New York. Handsomely illustrated pamphlet illustrating and describing the uses of Tarvia for preserving roads and preventing dust. The employment of Tarvia, a specially prepared coal-tar material, enables roads to be preserved and dust avoided, and this publication shows how successful it has been in many parts of the country.

Blowers

L. J. Wing Manufacturing Company, New York. Bulletin No. 7, devoted to the Typhoon Turbine Blower, showing the construction of this disc fan, combined with a steam turbine for the production of forced draft for steam boilers, together with illustrations showing its successful applications to various types of boiler furnaces. The use of the Typhoon blower in connection with heating furnaces is also illustrated, together with data and diagrams relating to the combustion of coal and the necessary supply of air.

Cyaniding

The Moore Filter Company, New York. Handsomely illustrated catalogue describing the Moore Slimes Process for the perfect recovery of gold and silver-bearing cyanide solutions from slimes, including illustrations of apparatus, arrangement of mills and data concerning operation and costs. The illustrations include examples of installations at various places in the United States, with letters from superintendents and managers concerning performances.

Reinforced Concrete

Trussed Concrete Steel Company, Detroit. Illustrated pamphlet describing rib metal and its applications in connection with the construction of floors, roofs, walls, arche sewers, etc., of concrete. The numerous applications of this material are shown by illustrations taken from actual work, and its usefulness demonstrated in all lines of reinforced concrete work.

Railway Material

Ohio Brass Company, Mansfield, Ohio. Catalogue No. 8, showing fully the extensive line of electric railway and mine haulage material manufactured by the Ohio Brass Company, including overhead line material, general construction material, track-bonding devices, third-rail insulators and car-equipment devices. The book is a handsome example of editorial and printing work, and contains valuable tables for reference, besides being fully indexed. This catalogue is one of the examples of the manner in which modern trade literature is contributing to the general stock of technical information.

Pile Hammers

Henry J. McCoy Company, New York. Illustrated pamphlet describing the "New Monarch" steam pile hammer and its application in connection with the driving of piles of timber, concrete and sheet steel. Details of construction are given, together with examples of numerous applications and a discussion of the advantages of rapid automatic action in a pile hammer in forcing piling into the ground without interruption of movement.

Counters

Schaeffer & Budenberg Manufacturing Company, Brooklyn, N. Y. Catalogue devoted to counters, engine registers and speed indicators, including several novel types of instruments. Attention is directed to the short-stroke counter, which counts when the lever acts through the short distance of 15 degrees; also there is noted a high-speed rotary counter for speeds up to 6,000 revolutions per minute. Electric counters are also listed, and the publication demands the attention of engineers and in all departments of activity.

Steam Engines

Fully illustrated catalogue S-75, of the Providence Engineering Company, Provdence, R. I., just issued, treats fully of their Corliss engines. It shows a number of installations of their engines and describes the details of their construction very thoroughly, especially those features which enable successful operation at high speed.

Much data of interest to all engineers are also given regarding floor space, horse-power ratings, rope driving, etc.

This company has also issued a separate bulletin which shows the unusual low friction losses and steam consumptions shown by the results of tests, the reasons for which will be found in their Bulletin S-75.

Copies of these bulletins are mailed by them on request.

Metal Corners

The Hunt Metal Corner Company, of Westboro, Mass., has issued a little catalogue under the title of "Protect Your Corners." It describes by text and illustrations the Hunt Steel Corner Bead, which they claim makes a perfect and lasting plaster corner. Their other products, such as the Hunt Metal Corner, for use on badly constructed and broken brick or terra cotta walls and for the corners of arches, the bull nose corner bead, the Hunt clamp corner bead, etc., are also treated of. Copies will be sent on request.

Safety Valves

An exceedingly unique and attractive as well as useful series of loose leaf catalogues is now being issued by the Crosby Steam Gauge and Valve Company, of Boston, Mass. Recently received are two, one devoted to their spring-seat valves, the other to their pop-safety valves, the former valve being primarily intended for high pressures and use in connection with superheated steam. These catalogues are very fully illustrated, printed in colors and issued in a series of different colored covers and are a good example of high-class printing descriptive of high-class products.

Castings

Buffalo Foundry & Machine Company, Buffalo, N. Y. A unique catalogue is just received from this firm in the shape of a trust company pass-book, with check protruding, and gives brief, yet clear, information concerning the exceptional features in the equipment of this concern. Their plant, operated by Niagara Falls power, is one of the largest and best-equipped ever built devoted to the jobbing trade, and produces castings of any size up to 200 tons in weight each. Illustrations show different departments of the plant and a few of its notable products, such as a 2,000 horse-power gas engine cylinder, 72,000-pound hammer frame made in dry sand mold, etc.

Storage Batteries

The Electric Storage Battery Company, Philadelphia, Pa. Illustrated pamphlet giving the principal features of their "Exide" battery, this battery being designed to take care of a large portion, if not the entire load, for short periods of interruption in cases of emergency so necessary in the present-day practice, where centralized generators distribute over large areas. They claim for this battery high discharge rates with high voltage, small floor space, light weight and low cost per kilowatt output, their batteries being in use by many of the large plants of the Edison Companies.

Scientific Books

The Norman W. Henley Publishing Company, New York, have just issued a condensed, envelope-size catalogue of all their publications, which will be sent free to any address in the world on application.

Recording Thermometers and Pressure Gauges

The Bristol Company, Waterbury, Conn. This company is now issuing new bulletins of nearly all their well-known recording instruments. Bulletin No. 125, descriptive of their Class 1 self-contained recording thermometers for recording temperatures, is just off the press. They manufacture an instrument especially designed for and now used to great advantage in many cold storage plants, which is fully described in this bulletin, which also contains a specimen record chart illustrating clearly the practical value of this instrument. Descriptions and illustrations are also given of the new models of Bristol thermometers.

Steam Hammers

The Buffalo Foundry & Machine Company, Buffalo, N. Y. An exceedingly handsome and attractive small catalogue describing the Bell steam hammer manufactured by the above firm, giving principal points of its design and construction in a concise form that will be appreciated by the busy man. The Bell hammer has met with a most flattering reception, there being over one thousand in use.

Diamondless Core Drills

Ingersoll-Rand Company, New York. Of much interest to the managers of coal, stone and mineral properties, as well as to the contractors on heavy construction, will be found the leaflet describing the Davis calyx "diamondless" core drill which this firm has just issued. Fuller information concerning their core drills will be found in their catalogue No. 91, just from the press.

Graphite Products

The Joseph Dixon Crucible Company, Jersey City, N. J., under the title of "Valuable Graphite Products," has just issued a useful little booklet, which contains many illustrations and full information concerning the practical uses of graphite in its different forms.

Feed-Water Heater

Power Plant Specialty Company, Chicago, Ill. Bulletin No. 103, describing the Vater open feed-water heater, and containing useful information for the engineer, architect and owner.

Economizers

The Green Fuel Economizer Company, Matteawan, N. Y. Bulletin No. 131, entitled Heat Economy in Paper Mills, and devoted to the advantages of the Green fuel economizer placed in the chimney flue, for obtaining without additional cost the large volumes of hot water required, not only for boiler feed, but also for washing pulp, for use in beater engines, for making bleaching liquor, etc. This important application of the economizer is demonstrated by illustrations of numerous installations at various large paper mills. Details of the construction of the economizer are also given.

Terminal Handling

THERE has been much said and published of late about railway rates and the cost of transport over long distances, and the subject is one which doubtless demands close attention, both of statesmen and of railway managers, the prosperity of the country being largely involved in the ease with which its products may be brought from the points where they are produced to the points where they can be sold.

At the same time it is not always understood how excessive a proportion of cost is involved in the delivery of material after it has reached the nominal terminal, and while it is yet a considerable distance from the real point where it is to be used.

Probably there is no more tedious, expensive and annoying method of delivering merchandise from railway station to warehouse or manufactory than the old-time plan of unloading it from the cars by hand, reloading it by hand again into carts or wagons, hauling it along streets and roads, and again unloading it at the point where it should have been delivered in the first place. In very many instances the combined costs of loading, delivering to the train, unloading and redelivering at the terminal exceed several times the entire railway charge, and yet this excessive burden is borne silently, while the railroad freight charge is made the burden of governmental investigation and of political recrimination.

Of course, it is impossible for every manufacturing establishment to be situated at the railroad terminal, and even if it were so fortunately placed, the railway service could not be expected to include delivery into the works as a portion of its transportation service. At the same time it is possible for most works to secure railway sidings or similar accommodation, and this much being obtained, it remains for the receiver of the material to provide his own appliances to supplement the shortcomings of the railroad delivery.

Terminal warehouses for the receipt of merchandise which is in cases, crates, or similar packages have been provided in many large cities, and others are in contemplation. There are other materials, such as coal, iron ore, sand, gravel, phosphates, etc., which are transported in bulk, and which must be handled, to use the old term, by manual labour, involving the shovel and the man behind it, or which must be received and delivered by some modern form of conveying system.

This latter is the natural evolution of the situation. The materials above enumerated, especially coal, which forms such an important portion of the traffic of many raliroads, could not, under present demands for power-house service, be adequately handled at all by manual labour.

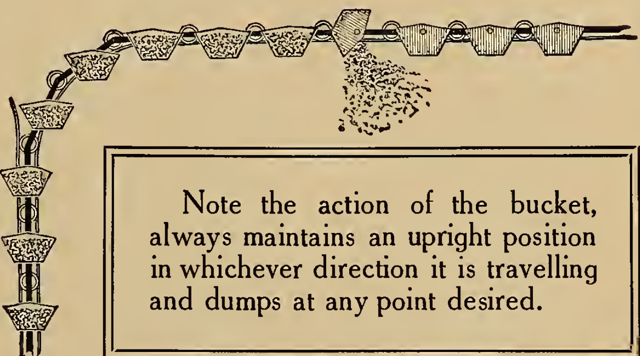
In nearly every large power generating station at the present day the railway is supplemented by the conveyor, which takes the fuel from the cars and rapidly and noiselessly delivers it to the storage bins above, whence it flows to the furnaces to be consumed as the demands of the boilers require. In like manner the resultant ash, or non-combustible, instead of being shoveled away by manual effort, is delivered to the outgoing cars and taken away as continuously as the fuel is delivered.

When the railway service connects with such mechanism, the onerous charges for terminal handling are largely avoided, and the apparatus for completing the delivery, which has been but imperfectly conducted by the railway, takes up the work and carries it to satisfactory conclusion with even higher efficiency than can be effected by the railroad itself.

When, however, as is too often the case, the scientific effort to secure efficient handling ends at the terminal, a weak link exists in the chain, to the detriment of the entire operation of transport.

"Hunt" Noiseless Bucket Conveyor

For handling dry materials or liquids



Note the action of the bucket, always maintains an upright position in whichever direction it is travelling and dumps at any point desired.

Noiseless in operation

Costs less for maintenance power and operation than any other Conveyor

Conveyor over Coal Storage Bins
Morgan & Wright Co., Detroit, Mich.

Handles Coal Ashes Ore Phosphates Sand Gravel etc.

Hoisting Towers
Cable Railways
Automatic Railways
Steam Shovels
"Industrial" Railways
Electric Storage Battery Locomotives

C. W. HUNT COMPANY

Established 1872

No. 45 BROADWAY
NEW YORK

Works: West New Brighton, S. I.
NEW YORK

Labour Costs in Manufacturing

IN the determination of the cost of a manufactured product it is common to divide this into several portions, these generally including material, machine charges, expense and labour. Of these the labour charge is generally one of the most important, and the profit or loss on a manufactured article often depends upon the extent to which the amount of labour expended in its production can be kept down.

This question of the labour cost often includes much more than the mere wages of the man attending the machine, and even when the speed of the tool is greatly increased and the direct labour charge proportionally reduced, there yet remains a considerable proportion of expense which originates in labour exerted in preliminary or subsequent operations. These may not be actual manufacturing processes at all, and thus cannot be diminished by increasing the efficiency of the machine tools themselves. They include the operations of bringing the material to the tool, the accurate placing of the job in the machine, the prompt removal of the finished work, and, in general, the maintenance of the continuous flow of work through the shop.

Such elements of labour cost may be diminished by skillful management, by the provision of such succession of jobs as shall avoid waiting for material, instructions and methods, and especially by the use of the most efficient appliances for the actual handling of the material.

Any attempt to determine accurately the time required for the machining operations performed on a machine part, and also the time involved in its handling, the sum of the two times forming the entire time of its passage through the shop, will reveal the extent to which non-productive movements must be included. These latter movements add to the cost of the product, not only because of the wages of the men by whom they are performed, but also because they are obliged to bear their proportion of the overhead charges and thus they offer one of the most important departments in which to effect economies.

Since the costs of these handling operations, as well as the expense charges based upon them, ultimately depend upon time, the most direct method of minimizing all elements of this department of cost is to do everything possible to shorten the time required for handling. This has been effectively done, so far as the transport of material into and out of the shop by the use of overhead traveling cranes by industrial railways, and by systems of overhead tramrail and chain blocks.

An important time-consuming detail, however, is found in the critical placing of the work in the machine itself, the determination of the precise position which it is to occupy during the operation of machining, and the removal from the scope of the tool with care, convenience and speed. Undoubtedly the best plan to reduce the time of this portion of the work is to provide each tool with its own chain hoist, and its own short run of overhead tramrail.

The mere provision of a chain hoist is not sufficient. A hoist for this service must possess such smoothness and precision of action that it enables the work to be placed in the exact position required. Furthermore, it must have such high mechanical efficiency that little or no portion of the effort of the mechanic is wasted in unnecessary exertion, the machinist himself must be able to perform the movements, while at the same time attending to the necessary adjustment before the tool, rendering him independent of labouring assistance and adding to his skill as well as to his strength. The installation of such handling appliances is one of the most effective means of reducing the element of labour costs, both at the tools and in the intervals between them.

A Matter of Minutes Only

Handling the finished boiler with a six-ton Triplex Block on a hand traveling crane.

TO put a chain around a boiler, hook it to a Triplex Block and then lift and move the boiler, is a matter of minutes only. Merely in getting ready you save 90% of the time usually wasted.

The Triplex Block with one man on the hand chain will pick up any load up to twenty tons. When the Triplex Block runs on an overhead track properly designed, two men can put the boiler on a flat car or truck before a gang of men would have begun operations with skids, rollers and tackle.

You may have a Triplex Block to try on your *own* work by just asking us or your nearest dealer.

CHAIN BLOCKS
- **4 styles:** Differential, Duplex, Triplex, Electric.
- **42 sizes:** One-eighth of a ton to forty tons.
- **300 active stocks:** ready for instant call all over the United States.

The Yale & Towne Mfg. Company

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The Coal Machine Problem

THE advent of machinery in any line of industry is likely to transform its methods and to change its products or results more or less. The work and the workers make concessions and accommodate themselves to the ways of the machine to secure its advantages. The rock drill, for instance, has radically changed the planning and the working of the world's great engineers. From before the time of the Romans down to the building of the first Croton aqueduct water was conducted in open channels, with just enough descent to permit an easy flow; and to secure the necessary level the line meandered tortuously along the edges of the hills, and costly works were required to cross the valleys and the streams.

Now the rock drill makes the pressure tunnel possible and cheap, and it is driven by straight lines from point to point. In this respect the coal machine is more or less an anomaly, in that it gets so few and small concessions from the work it undertakes to do. Mining conditions can be but little changed to accommodate the machines, and it is the machines which must be adapted to the conditions. The coal mining machine undertakes to supersede the hand-worked pick, and it must work in just the same situations in which the hand pick has been worked. Generally, too, the man who has worked the pick, perhaps for years, becomes the manipulator of the machine when it is introduced. It is, of course, at all times largely dependent upon the skill and judgment of the man who handles it, and as the hand pick is of widely different effectiveness in different hands, so the machine makes different showing, according as it is handled.

As the conditions of coal mining vary so much, especially as to thickness and pitch of the seam and the hardness of the coal, it is not to be expected that any one style or size of machine will be universally suitable, and we might even expect ultimately a wider series than yet exists. The coal machine may, in the long run, expect fair play, and will win upon its merit.

From official notes upon coal mining machines, so far as they have been fairly tried, the following claims have been made for them: There is an increase in the proportion of lump coal produced, a greater yield per acre, reduced working cost, reduction in the amount of explosives required, reduced cost for timbering, and fewer roof falls; larger daily wage for the collier, while relieving him from the most laborious and dangerous work.

Coal-cutting machines, so-called, are not new, having been tried in Great Britain more than half a century ago, but with so little success or encouragement that, so late as 1902, there were only 166 machines in use. In 1907, however, there were 1,493 machines.

With regard to coal machines in the United States, there are some interesting figures, but not very closely up-to-date. The number of machines in use increased from 7,663 in 1904, to 9,184 in 1905, and to 10,212 in 1906, 5,911, or 58 per cent., of this number being of the pick or puncher type. The percentage of increase in the production of machine-mined coal in 1905 over 1904 was greater than the percentage of increase in the total production. In 1906 the quantity of machine-mined coal was 15,451,075 short tons greater than in 1905, while the total production of bituminous coal increased 21,534,643 tons, showing that 72 per cent. of the increase was in the machine-mined product. The average output for each machine in use increased from 10,258 tons in 1904 to 11,258 tons in 1905, and to 11,638 tons in 1906. The percentage of machine-mined coal to the total production in 1899 was 23; in 1900, it was 25.15; in 1901, 25.68; in 1902, 27.09; in 1903, 28.18; in 1904, 28.78; in 1905, 33.69; and in 1906 it was 35.10.

INGERSOLL-RAND CO.

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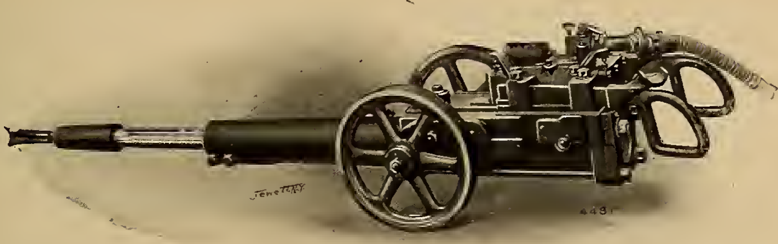

"NEW INGERSOLL" COAL PUNCHES

The coal puncher is to coal mining what the rock drill is to metal mining—the first essential of profitable mining.

The "New Ingersoll" holds the same leadership among punchers that "Sergeant" and "Little Giant" Drills have been universally accorded in the rock drill world.

This leadership rests entirely on the question of performance. **It is the endorsement given by the trade to the large capacity, low power consumption, splendid construction and good wearing qualities of the "New Ingersoll".**

The "New Ingersoll" is a **quality machine,** built as well as a puncher can be made and repeatedly proved to meet the requirements of manager and miner.

Thousands are in daily use. Single customers are using hundreds of them. Practical experience has verified every claim made in their favor.

When you adopt the "New Ingersoll", you at once range yourself on the side of the vast majority of quality buyers.

We have just issued a new Bulletin 5002 on the "New Ingersoll". Shall we send it?

Products:

- AIR COMPRESSORS
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Fireproof Windows

DURING the number of years in which engineers, architects and builders have been endeavoring to perfect methods of fireproof construction, certain details have eluded solution until recently. It is well understood that fireproof construction must involve the use of non-combustible material, usually material which has already been through the fire in the course of its manufacture, such as cement, brick, tile, and the like. A building, however, cannot be made entirely solid; it must have openings for light and air, as well as for communication, and the problem in modern fireproof construction includes this portion of the work as well as the wall and floor construction.

It is not an easy thing to make a hole fireproof, and yet the holes in a building form the passageways through which fire is communicated from one portion to another. If the holes can be rendered impervious to fire, a long step forward in fireproof construction has been made.

Obviously this means that all wooden construction must be abandoned. It is useless to put wire-glass into a wooden sash, which can be burned out and leave the protection to fall away. Apart from its combustible nature, a wooden sash is ultimately affected by moisture and decay, and hence is lacking in the permanence which is an essential portion of a satisfactory design.

Under such circumstances it has become evident that some fireproof material should be used for window sash, and there is no material which has shown such applicability as steel. Steel sash, therefore, have been considered as essential, especially for fireproof factory buildings, rendering the window framing as thoroughly fireproof as the walls in which they are set.

Not all steel sash, however, are equally desirable; there is the same opportunity for skill in design and construction with steel as a material as there has always been with the wooden structure.

The framework of a window necessarily obstructs some of the light, and the well-designed sash has this obstruction reduced to a minimum by making the sections narrow, a construction which also permits the use of proper depth and consequent stiffness in the direction of wind and other stresses.

If, as is usually the case, the main sash is a fixture, and a hinged portion is provided as a ventilator, this ventilator must be considered practically as a separate window, and demands proper design to insure strength when closed to form a portion of the fire protection, and also tightness against wind and rain in stormy weather.

Usefulness and security must necessarily come first, especially in such a matter as fireproof construction; but because a thing is mechanically correct it does not follow that it must be unsightly. A steel sash can be made as effective in appearance as one of wood, and, when well finished and trimmed, it is open to none of the objections which have been made to the use of steel in designs which have neglected these considerations. Handsome is that handsome does applies, above all, to such essentials as the relation of performance to appearance in such a serious thing as defense against the ravages of fire, and the steel sash has already attained the position of looking well because it serves its purpose well.

The perfection which has been attained in modern fireproof construction is largely due to the extent to which engineering ability has been directed to its improvement, and also to the manner in which details have been cared for. It matters not if the broad features of fire protection have been considered if some loopholes have been left through which the enemy can enter and the destruction spread. The job must be complete in every detail or it is defective as a whole.

Controlling Mechanism

AN important department of the work of the mechanical engineer is that commonly entitled "transmission of power." This name is fairly comprehensive, but yet it does not convey the full scope of this most necessary sub-division of engineering work. Power is generated by some form of prime mover, and many able engineers are devoting their energies toward the improvement of the steam engine, the combustion motor, the hydraulic turbine, and all the details for the conversion of the latent sources of power in Nature into a form of kinetic energy which is capable of utilization. Another body of engineers and mechanicians is continually at work devising all kinds of machinery for performing the work of the world to the greatest advantage, and their products fill our workshops with activity and our manufactories with productive appliances.

Between these two great bodies of workers comes the transmission engineer, occupied with the design and construction of devices for connecting the motor to the machine, with the delivery of the power from the point where it is generated to the place where it is to be used.

The word "transmission," however, does not fully convey the broad scope of this department of work, as has already been indicated. It is not enough to send the power from the engine to the tool; it must be sent in a manageable manner, it must be controlled, held in check, released, stopped, started, and, in general, it must be rendered completely subservient to the demands of the intelligence by which it has been set at work.

In some cases the control is effected directly at the point where the power is generated, and many early systems had no other method of management. Probably such a method appears to-day in its most important form in the case of the steam locomotive, in which the hand of the engineer on the throttle regulates the speed and power of a machine which may reach a capacity of 2,000 horse-power.

When, however, as is usually the case in manufacturing establishments, the power generated at the engine is to be distributed to a number of points, while the total amount is maintained fairly at an average, there must be some means of stopping and starting the various sub-divisions of the transmission system, from the main branches down to the individual machines. Here it is that the modern effective clutch comes in, enabling, as it does, the gradual start, the prompt release, and the complete control of any portion of a transmission system without disturbing in any way the continuous and uniform motion of the prime mover. The clutch thus bears to the mechanical transmission system the same relation that the electric controller does to an electrical distribution of power, and its certainty, capacity and reliability are essential to the satisfactory operation of any system.

It is now well understood that an important element in the proper operation of a machine lies in the gradual application of power in starting, avoiding shocks, and enabling inertia to be overcome gradually. At the same time, it often becomes necessary to disconnect a machine instantly from the source of power, both in the course of regular operation or because of some immediate emergency demand. The same clutch must be able to serve both purposes, and if it cannot do this it fails of rendering full satisfaction. When to these essentials of operation are added the requirements of ease of installation, freedom to inspection and repair, stability and strength in operation, and entire convenience of control, it will be seen that the problem of clutch design is no simple one, but calls for the combination of mechanical ingenuity and thorough practical experience.

Manufacturing News

Albert Spies

ALBERT SPIES, who for fourteen years was editor of CASSIER'S MAGAZINE, died suddenly on August 16, 1910. Mr. Spies was born in 1862, and was graduated as mechanical engineer from the Stevens Institute of Technology in 1881. After several years' experience in engineering work and in technical journalism in connection with the "Iron Age," he became, in 1893, editor of this magazine, a position which he retained until the close of 1906. In 1904 he added to his work on this magazine the conduct of the "Electrical Age," but relinquished both to become editor of the "Electrical Record" in 1907. About a year ago he undertook the establishment of a new periodical, entitled "Foundry News," devoted to the general foundry trade, and at the time of his death he was both proprietor and editor of that publication.

Mr. Spies was a member of the American Society of Mechanical Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and the Engineers Club of New York.

A Self-Propelled Machine Shop

THE North Coast "Short Line" Railroad, of which Mr. Robt. E. Strahorn is president, is still forcing its way through central and western Washington, from Spokane west to the rocky slope of the Cascades. The north coast passes through the most fertile, irrigated valleys in the State, and will cross the Snake and Columbia Rivers, the latter in two different places; at the present time just completing the bridge at Burbank, across the Columbia, at a cost of $1,000,000. This line is the Walla Walla extension, which will probably build east through the Blue Mountains and make connections with some eastern line.

The ever-expanding needs of transportation facilities are still inadequate to meet the demands of this great Northwest.

Crossing the Cascades at a minimum grade of 1.4 per cent. we drop down on the western slope with an excellent grade, where we join with the Pacific Coast extension, passing through this State's greatest and most beautiful forests. Emerging out into the open, the North Coast

NORTH COAST MACHINE CAR

stretches out north and south, connecting Seattle, Tacoma and Portland and an outlet to San Francisco and the Orient.

Engineering experience has solved a problem, whereby the North Coast has settled on a low pass through the Cascades.

The line now building from North Yakima to a point on the Columbia in Walla Walla County, making connections with the O. R. & N., will be completed and in operation early this year for the fall trade.

The North Coast equipment is all new, and of the very best and latest designs, including two gasoline motor passenger cars for the local business.

The advance in mechanical appliances, which will be used in construc-

INTERIOR OF MACHINE CAR

tion work, has been very well planned.

It was deemed necessary to devise a way for repairs for locomotives and other equipment, until such time as a permanent shop could be located and erected. Herewith we show cuts of equipment already on the ground —motor car and machine car. The interior of machine car shows a 12 horsepower Fairbanks-Morse vertical gasoline engine, oil-cooled. The engine is connected to a friction clutch and to the wheels of car by sprockets and chain, which enables the operator to do switching with the car and also to move from one station to another, doing work without assistance of a locomotive, making eight or ten miles an hour. Tools in car are as follows: One 23-inch engine lathe, one 16-inch shaper, one 1½-inch bolt cutter, one 6-inch pipe threading machine, emery wheel, and a 22-inch vertical drill. The dimensions of car inside are 39 feet 10 inches long, 9 feet 6 inches wide and 9 feet high.

The gasoline engine when running shop 12¾ hours consumed four gallons gasoline, with two men working in car on different tools as the work came in. The engine has been running nine months without costing one cent for repairs.

Practical Demonstrations of Oxy-Acetylene Welding

AT the recent conventions of the Master Car Builders and the Master Mechanics, at Atlantic City, there was among the various exhibits a demonstration booth of the oxy-acetylene welding apparatus, made by the Davis-Bournonville Company, of 80 West Street, New York. At this booth demonstrations were made of welding horizontal steel plate from the under side; welding patches in fire-box sheets, replaning heavy castings used on locomotives and cars, as well as cutting steel and iron, other than cast iron, to the thickness of several inches. These operations attracted much interest, not only among the railroad men present, but also among others who saw them. The result was that various repair jobs demanding immediate attention at Atlantic City were brought to the exhibitors, who showed the practical value of the apparatus in performing these special jobs.

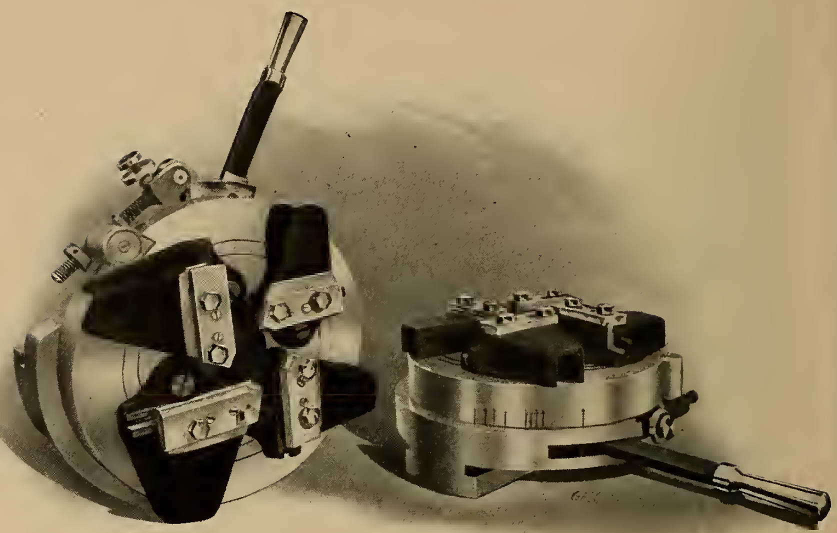
Thus the motor of the United States Wave Power Company, installed on the pier, met with an unfortunate accident, which would have necessitated closing down for at least a week and the sending of the broken parts to Philadelphia for repair. The deranged portion of the buoy, and also broken walking beams were welded by the oxy-acetylene apparatus and the machinery was in operation again within two hours, the welded parts holding perfectly and standing severe strains under high seas.

In like manner a machine belonging to the Carborundum Company, of Niagara Falls, was repaired. This machine had been allowed to drop while unloading, and two cast-iron supporting arms were broken. The otherwise useless machine was quickly repaired by oxy-acetylene welding and made available for immediate service. A Cincinnati shaper had its vertical slide broken off for nearly its entire length, crippling the machine. In two hours it was welded successfully and the tool was taking a ¾-inch cut without difficulty.

These live examples of the capability of the apparatus should cause manufacturers to "sit up and take notice."

Cement Waterproofing

AN exceedingly valuable pamphlet has recently been issued by F. William Stocker & Co., Inc., general sales agents of the Hydro-Tar Waterproofing Company, 34 West Thirty-third street, New York, entitled "Some Facts in Regard to Waterproofing." It contains much of interest concerning the modern method of waterproofing cement, stone, etc. A copy can be obtained on application.



THE LANDIS STATIONARY DIE HEAD

Stationary Die Head for Pipe Threading

THE illustrations given herewith show a stationary die head for pipe threading as manufactured by the Landis Machine Company, Waynesboro, Pa., using the Landis type of die with a manually operated die head.

This head is made especially for use on pipe threading machines wherein the pipe revolves and the head remains stationary, the dies being opened and closed by hand. The head is made entirely of steel, as are also the die holders. The head can be mounted on the carriage of any of the standard pipe machines and can be handled in the same manner as the other styles of heads, but has the advantage of the long-life die as illustrated herewith.

The chaser for these die heads can be made to good advantage from high speed steel, as they never require to be annealed, rehobbed or retempered, and their life is many times that of any other die. The sharpening of the die is a simple operation and is taken care of by grinding on the ends of the chasers and again setting them to the correct cutting position in the holders by means of a small gauge furnished with your die head.

The heads are made in standard sizes to take work up to and including 4 inches. One of the great advantages in this die for threading pipe is the fact that one set of dies will cut all the diameters coming within the same pitch. As there is but one pitch covering the sizes from 1 inch to 2 inches inclusive, one set of dies covers this range. The same is true on the other pitches.

HOLDER FOR LANDIS DIE HEAD

Among the illustrations is shown one of the holders used for pipe for threading where it is not necessary to cut very close to a shoulder. The clamp with which this chaser is held is what is known as their mill clamp, which, besides holding the chaser rigidly, protects the chaser in case

the pipe splits, the latter occurence happening very frequently. The clamp, as shown in the cut, comes down over the throat of the die and is rounded out near the cutting point so as to act as a guide for rough ends, and at the same time when a twister occurs in the pipe the strain is thrown in great part on the clamp, thus protecting the die in such manner that the liability to breakage is very small. In case of threading close to a shoulder a clamp is used which comes flush with the front edge of the chaser only, thus permitting the die to run close up against the shoulder as in threading short nipples, etc.

The advantages of the die are many. It admits of cutting speeds from 25

THE LANDIS CHASER

to 100 per cent. higher than the hobbed type of die, and the rake can at all times be ground to suit the quality of the material in the pipe to be threaded. Much of the merchant pipe on the market to-day is very stringy and tough, but with this type of die it is possible to get the ideal cutting condition and results can be produced that are second to none.

The heads are graduated for setting the dies to the different diameters to be threaded. The head is opened and closed by hand, and when in the closed position the die is rigidly locked, but is opened and closed freely by means of the lever.

The advantages of this head over other types of pipe threading die heads lie in the life of the dies, the higher cutting speeds that can be obtained, and the flexibility of the die to the different qualities of material to be threaded.

All dies are made to interchange perfectly, and if one chaser of a set should be worn out in advance of the others this single chaser can be replaced without replacing the entire set.

Dies of any one pitch will interchange on any of the die heads so long as the pitch is within the range of the head. For example, dies for threading 1-inch pipe on the 1-inch head will also thread 1-inch pipe on the 2-inch head, or *vice versa,* thus avoiding the necessity of carrying a large assortment of dies to cover the range of work when using a number of these heads.

The heads are made in standard sizes, ranging from ¼ to 4 inches.

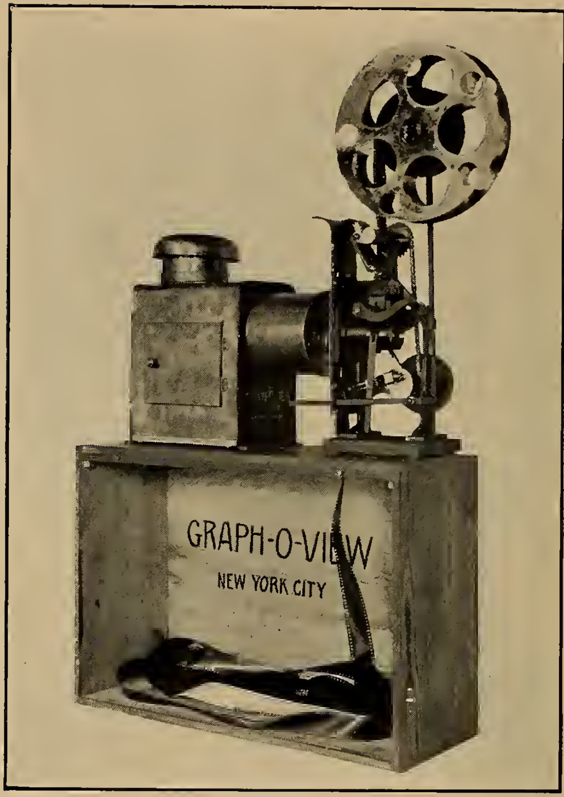
Cableways at Panama

A LETTER of endorsement recently given by a high official of the Isthmian Canal Commission to the operator who had charge of the eight Lidgerwood cableways used in building the Gatun locks during the preceding eleven months, contains incidentally a remarkable record of efficiency of the cableways. This passage reads as follows:

"These cableways so far as delays from breakage or repairs were concerned, while working 12½ hours per day, have been kept up to an efficiency of 99 per cent."

That is to say, that during this whole period only one per cent. of time was lost on account of making repairs.

The cableways referred to are eight of the thirteen cableways designed and built by the Lidgerwood Manufacturing Company for the Isthmian Canal Commission. The other five are used for handling the broken stone and sand for the con-



A FAMILY MOVING-PICTURE MACHINE.

crete, taking it from barges and delivering it to the storage yards some 600 feet away on the average. The total to be handled will be 2,000,000 cubic yards of broken stone and 1,000,000 cubic yards of sand.

The eight cableways for building the locks are used for placing the concrete and reinforcement and also for handling forms.

They are traveling cableways of 800 foot span, operated electrically. They are handling on every working day more than 3000 cubic yards of concrete. Up to June 4th there had been placed in the Gatun Locks and its auxiliary plant 437,461½ cubic yards of concrete. The amount placed in the five days from May 31st to June 4th inclusive was 16,809 yards, an average of 3361 cubic yards per day.

A Household Moving Picture Machine

THE moving picture machine is now so firmly established as a means of entertainment and instruction that it needs no inducement to add to its popularity as a public apparatus. The machines now on the market, however, are intended for use in public halls and are necessarily powerful and costly. The machine shown in the illustration, however, is intended for general sale for use in families, schoolrooms and similar places and can be furnished at a price no greater than is requried for a good projecting lantern for ordinary slides. Since it is now possible to rent films of almost unlimited variety, covering illustrations of animal life, such as insects, birds, reptiles, etc., or studies of physical or optical phenomena, besides

the wide range of popular subjects, the opportunities afforded by such a machine from the educational point of view are very great.

The machine uses the standard films, it gives a picture free from flickering and unsteadiness, and it may be used either with electric light or with incandescent gas burner, so that it is available in almost any locality. It is the only home machine which has been passed upon favorably by the departments of Water Supply, Gas and Electricity, and the Fire Department of New York City, so that its safety is assured. It may be set up for use in a minute, and it forms an essential piece of apparatus for every school room, clubhouse and intellectual family in the country.

The manufacturer desires to make arrangements for its extensive manufacture and sale, and any communications addressed to M. P. M., care CASSIER'S MAGAZINE, New York, N. Y., will receive prompt attention.

The Sebco Fascut Drill, designed for use where a deep, sharp-cut hole is to be drilled, is an evolution of the Star Expansion Bolt Company's Star Stone Drill. The Sebco Fascut is a five-pointed drill. Where a hole is to be drilled in a hurry—where a mechanic cannot stop to waste time with a slower and more clumsy tool—the Sebco Fascut is admirably adapted. A raised head-on drill prevents clotting or binding, a very important feature.

This drill can be handled exactly the same as any stone drill. The difference between the ordinary stone drill and the Sebco Fascut is that the faster and more efficient drilling power of the Sebco Fascut renders it a more profitable investment. A 70-page superbly illustrated catalogue of Star Products will be sent to any-one upon request, together with free working samples of several Star Products, by addressing Star Expansion Bolt Company, 147-149 Cedar Street, New York City.

THE preface to the eighth edition of Kent's Mechanical Engineers' Pocketbook, soon to be issued by John Wiley & Sons, New York, states as follows:

During the first ten years following the issue of the first edition of this book, in 1895, the attempt was made to keep it up to date by the method of cutting out pages and paragraphs, inserting new ones in their places, by inserting pages lettered a, b, c, etc., and by putting some new matter in an appendix. In this way the book passed to its seventh edition in October, 1904. After 50,000 copies had been printed it was found that the electrotype plates were beginning to wear out, so that extensive resetting of type would soon be necessary. The advances in engineering practice also had been so great that it was evident that many chapters required to be entirely rewritten. It was therefore determined to make a thorough revision of the book, and to reset the type throughout. This has now been accomplished after four years of hard labor. The size of the book has increased over 300 pages, in spite of all efforts to save space by condensation and elision of much of the old matter and by resetting many of the tables and formulæ in shorter form. A new style of type for the tables has been designed for the book, which is believed to be more easily read than the old.

The same publishers announce "Engineering Reminiscences, 1855-1882," by Charles T. Porter, a work showing the origin and growth, in the author's mind, of the high speed idea, now completely presented for the first time. The development of the governor is given, as well as the wonderful fact that the secret of its astonishing action had remained unobserved for fifty years, and its discovery by the author will undoubtedly command the close attention of all engineers. The book is filled with incidents and shows dramatic situations.

Charles T. Porter

CHARLES T. PORTER, the veteran mechanical engineer, died from old age at the home of his son in Montclair, N. J., on August 29. Mr. Porter, who was so well known in engineering circles, was born at Auburn, N. Y., in 1826, graduating from Hamilton College in 1845, and was admitted to the bar in 1847.

He practiced law first in Rochester and later in New York, but abandoned the legal profession after a few years for mechanical pursuits, in which line of effort he was destined to be so widely known. During long practice as a mechanical engineer he devoted himself especially to steam engineering, which owes much to his many valuable inventions. As early as 1859 he patented the central counterpoise governor for steam engines, in which the resistance from friction was practically eliminated and the theoretical action of the "conical pendulum" was closely realized. His next patent, granted in 1861, was for an isochronous centrifugal governor for marine engines. This governor was new in principle, the resistance to the centrifugal force of the revolving balls being furnished by a spring, to which was given such an amount of initial compression that its further compression by the expansion of the balls caused its resistance to increase in the same ratio in which the centrifugal force of the balls was increased by the enlargement of their circle of revolution, thus making the two counteracting forces in equilibrium in every position of the balls, at a constant number of revolutions per minute, a principle which came into extensive use in governors revolving about the axis of the engine shaft.

With Mr. John T. Allen, in about 1860, Mr. Porter gave his active attention to the now well-known Porter-Allen engine, the valves and valve motion of which were wholly the invention of Mr. Allen, Mr. Porter devoting himself to its constructive features, which were for some time peculiar to it.

These constructive features designed by Mr. Porter were so successful that most of them are now more or less in general use.

He made an extensive study of the theoretical and practical conditions which are involved in the employment of high rotative speeds in stationary steam engines, being the first manufacturer of these engines to employ such speeds with success. Many builders and power users of the time ridiculed his theories and prophesied failure for their embodiment, pointing out the impossibility of proper admission and exhaust under the conditions he advocated. These same men lived, however, to claim and prove perfect steam distribution for engines at even higher piston speeds.

Mr. Porter was one of the organizers of the American Society of Mechanical Engineers and served as a manager during 1882-85 and as a vice-president from 1886-1888, and was conferred the distinction of honorary membership in the society in 1890. He was a frequent and valued contributor to its transactions. He was also well known as the author of a number of essays, among them being "Mechanics and Faith; a Study of Spiritual Truth in Nature."

In 1909 he was awarded the John Fritz medal, the other recipients thus far having been Lord Kelvin, Alexander Graham Bell, Thomas A. Edison and George Westinghouse.

The results of Mr. Porter's endeavor during later years, with which all engineers are familiar, well fulfilled the promise of his early career.

Mr. Frank Koester, of New York, in an important paper presented before the recent convention of the Society for the Promotion of Engineering Education, held at Madison, Wisconsin, discussed in detail the educational system of the German Technical Universities. He also analyzed the conditions and standing of the German engineer as compared with our own.

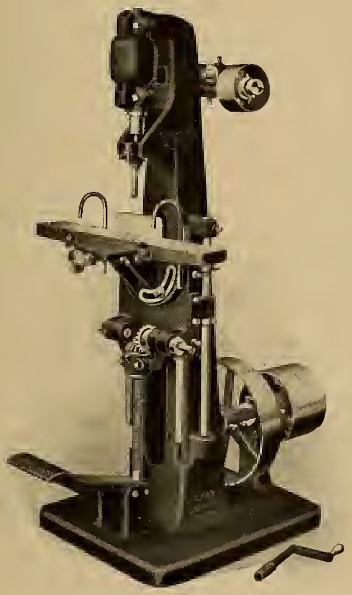
A Handy Tool

WE are pleased to call our readers' attention to something of special interest to them on this page in the way of a vertical hollow chisel mortiser, manufactured by J. A. Fay & Egan Company. It will be found a very handy and durable tool for the class of work intended.

This machine will mortise to a depth of 3 inches or 6 inches by reversing the stock. It accommodates chisels from ¼ inch to ¾ inches square.

Frame is a single piece casting with good floor support, and is perfectly rigid.

Table is 4½ inches wide and 30



VERTICAL HOLLOW CHISEL MORTISER.

inches long and moved by foot power a distance of 6 inches. It is provided with clamps to hold the stock and angles 40 degrees in either direction. It is adjusted up and down by crank and bevel gears, and is gibbed to the column of machine, and is provided with stop rod to regulate depth of mortise.

Chisel mandrel is made of the best grade of crucible steel and runs in self-oiling bearings lined with genuine babbit.

For further information concerning this new tool, you are invited by the manufacturers to write for large illustrated circular. The proper address of the manufacturers is 226-246 West Front street, Cincinnati, Ohio.

Producer Gas for Power and Fuel

Attention is called to the rapid increase in the use of producer gas power in the United States in an attractive and interesting catalogue just issued by the Syracuse Industrial Gas Company of Syracuse, N. Y. The book contains a table showing the comparative cost of power and much information concerning producer plants.

Charles F. Kenworthy, until recently with the engineering department of the American Brass Company, and formerly engaged by the Kenworthy Engineering Company, has been engaged by the Rockwell Furnace Company, to represent them in the New England States and Canada.

Mr. H. J. F. Porter has been engaged during the past summer in an investigation of hygienic conditions and their effect on the efficiency of the employees in manufacturing establishments in Pittsburg for the Russell Sage Foundation.

The Golden-Anderson Valve Specialty Company, Pittsburg, Pa., report that the United States Steel Corporation have ordered three hundred Golden-Anderson cushioned triple-acting non-return valves for the protection of their power stations. This company manufactures a very full line of valves for all purposes. The Golden-Anderson triple valve can be tested at any time without interference in the operation of the plant, it being entirely automatic.

THE LATEST CATALOGUES

In writing for Catalogues, please mention Cassier's Magazine

Cassier's Magazine invites manufacturers and others to send it their catalogues as issued, both for mention in this department and for the very complete library of catalogues which it maintains.

Machine Snop

Charles E. Dressler, 388 Second avenue, New York City. Catalogue containing Hints to Inventors, discussing the facilities possessed by the establishment for experimental work, the development of inventions, electrical testing and designing, and the production of models of all kinds for manufacturers, colleges, etc. Especial attention is given to aiding inventors to realize their ideas in practical form.

Drop Hammers and Forgings and Forged Tools

An exceedingly attractive and valuable series of catalogues has recently been issued by the Billings & Spencer Co., of Hartford, Conn. The series consists of five books of a most convenient size, each book treating of one class of their well-known products, as follows:

1. Machinists' Tools, etc. One hundred and twenty-eight pages of text, with a carefully arranged index and over a hundred half-tone illustrations.

2. Automobile Forgings and Tools. Sixty pages of text describing fully this branch of their business, a branch that has grown year by year with the growth of the automobile industry, illustrated by 60 half-tones.

3. Drop-Hammers and Forgings. Sixty pages of descriptive text, illustrated with more than thirty half-tones, both text and illustrations printed on tinted backgrounds of white paper. Contains very full information concerning their drop-hammers and forging machinery, and also a large line-drawing, showing all details of the construction of their latest hammer. In addition, much information of general interest to all drop-hammer users is given.

4. Fine Tools and Specialties. An exceedingly attractive and well-arranged example of modern high-grade printing, containing 19 illustrations of their well-known specialties, such as caliper gauges, Billings' improved pocket calipers, rules, depth gauge, micrometer holders, jewelers' anvils, Billings' patent vises, and combination vise, clamp and anvil, combination magazine knife and screw-driver, etc.

5. Drop-Forged Commutator Bars. Fully descriptive of their well and favorably known commutator bars.

Alternators

Ideal Electric & Manufacturing Company, Mansfield, Ohio. Bulletin No. 1051, illustrating and describing revolving field alternators, types "F" and "FW," especially adapted for use in small power plants and isolated plants delivering single and polyphase currents. The machines are described in detail, and data and results of performances are included, including characteristic curves, and temperature curves when operating under full load.

Conveyors

The Brown Hoisting Machinery Company, Cleveland, O. Special catalogue devoted to modern ore and coal handling machinery, and containing more than one hundred full-page illustrations of large installations of cranes, tramways, conveyors, and loading bridges constructed by the company for the largest concerns in the country. A remarkably effective and handsome publication of a most important department of engineering work.

Pneumatic Hammers

Ingersoll-Rand Company, New York. Catalogue of the Imperial Type "E" pneumatic hammers for chipping, riveting, calking and similar work. Various sizes and forms are illustrated, with tables of dimensions and data, together with duplicate-part lists for use in ordering. Some valuable information upon the right use and care of pneumatic tools is appended.

Acetylene Welding

Davis - Bournonville Company, 00 West street, New York. Pamphlet describing the quick repair work executed by the oxy-acetylene apparatus in connection with the exhibitions at the recent M. C. B. and M. M. conventions at Atlantic City, and showing how apparatus intended for an exhibit was in continual demand for local repairing.

Pumps

De Laval Steam Turbine Company, Trenton, N. J. Handsomely illustrated Catalogue B, devoted to the De Laval High Efficiency Centrifugal Pumps, and including a technical discussion of the present status of the centrifugal pump, its characteristics and applications. Numerous illustrations are given of various types of centrifugal pumps, and the use of the electric motor and the steam turbine for driving them, together with data and results of tests, and descriptions of installation.

Artesian Pumps

Weber Subterranean Pump Company, 90 West street, New York. Reprint of article describing the Weber positive displacement pump for use with compressed air.

Perforated Metals

Hendrick Manufacturing Co., Carbondale, Pa. Handsome catalogue illustrating and describing a great variety of perforated metals for use in constructing revolving screens for coal, ore, etc. The perforated metals are supplied in steel, galvanized iron, copper, brass and other materials, and their superiority over wire cloth for this purpose is fully set forth. A variety of manufactured screens is also shown, together with elevator buckets, and material for conveyor troughs, chutes, etc. A selection of useful tables relating to sheet metals is appended.

Water Softeners

Dodge Manufacturing Company, Mishawaka, Indiana. Pamphlet entitled "Saving Fuel" and devoted to the discussion of the objections to the use of hard water in steam boilers and the economy effected by the prevention of scale attained by the use of a water softener. The Eureka water softener is illustrated and described, and its effectiveness in the purification of feed water attested by numerous users.

Thermit Method of Pipe Welding

An illustrated pamphlet, issued by the Goldschmidt-Thermit Company of New York, describes their process by text and illustration.

Gravity Self-Closing Fire Doors

Catalogue describing their "Never Fail" device for the self-closing of fire doors, very fully illustrated, with many diagrams showing the working of their door-closing devices, and a number of letters from firms using them, has been received from The Victor Manufacturing Company of Newburyport, Mass.

Scientific Books.

The Branch Publishing Company, Chicago. Catalogue of books on engineering and electricity, especially adapted for the operating engineer, and devoted to steam boilers, steam engines, and electric generators, and suitable for preparation for examinations and practical engineering work.

The Reduction of Expense

EVERY manufacturer is interested in the vital question of the cost of his products. The magnitude of his sales depends largely upon the lowness of the selling price, and the selling price can be kept down only by continual vigilance in watching every detail of manufacturing cost.

Some of the elements of cost are inherent in the manufactured article; they increase or decrease in direct proportion to the number of pieces produced. Such elements are the material of which the article is composed; the piece price which may be paid to the workman and similar items; these can be kept down only by judicious buying, by the avoidance of wastes and by judicious agreements with employees.

Other elements of manufacturing cost are not dependent upon the number of articles produced, but must be considered as belonging to the total output of the establishment. Some of these are well known under the name of general expense and include rent, or interest on cost of plant; motive power, depreciation, office expense, general administration and the like. They may be distributed as a percentage of labor cost, as a time burden, or in some similar manner. Between these two well considered elements comes another group, not so easily distributed, more difficult to account for and sometimes most difficult to reduce. This group includes the operations of handling and involves the movement of the material through the establishment. The cost of handling, sometimes excessive, cannot always be placed where it really belongs, and its distribution is sometimes a question for discussion.

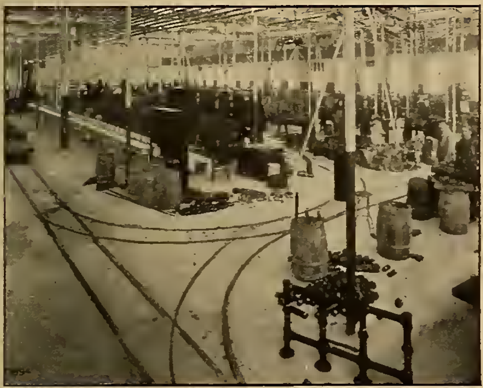
There need be no discussion, however, as to the best method for the reduction of the cost of handling, it is the one item which can surely and effectively be minimized by the substitution of mechanical appliances for human effort.

It has been said that "of all inventions, the alphabet and the printing press alone excepted, those inventions which abridge distance have done most of the civilization of our species." This is doubtless true of the steam railway, and in a similar sense it is true of the industrial railway, the means which enables material to be transported with a minimum of time, labor and cost, to any part of a workshop, regardless of bulk or weight. The industrial railway is to the manufacturing establishment what the great trunk line railroad is to the country through which it passes. Possessing the same degree of flexibility, with turn-outs, curves, switches, turn-tables, crossings, etc., and equipped with cars adapted fully to the requirements of the material to be transported, the industrial railway forms a miniature system of transportation and a means for maintaining the circulation as essential to the life of a shop as of a living being.

The increase in the efficiency of an establishment by the introduction of an effective system of transportation is not measured alone by the cost of the human labor which it supersedes. The operations of the entire shop are accelerated just in proportion as the movement of raw material inward and finished products outward is improved.

It is not usual in shops which are run in the antiquated methods to find material waiting to be machined; the old plan was for one job to be completed, for laborers to be sought to remove it, and for more laborers to be brought to transport the succeeding piece. The advent of the industrial railway changes all this. Every machinist knows that his next job will be at hand as soon as he can receive it; the foundry knows that the castings will be cleared away and material delivered without delay, and the shipping department and storerooms are sure of prompt and effective service. The industrial railway "tunes" the whole place up.

A Paying Investment
Hunt "Industrial" Railway



No. 0994.—Machine Shop and Shipping Department, Utica Drop Forge and Tool Co, Utica, N. Y.

will reduce the pay roll more than any other system.

It will increase the output of works or of factory at the same expense.

One company installed this system and their pay roll was reduced $24 per day and in addition the capacity was increased.

Simple to install, as an ordinary workman can lay it down.

THE flexibility of the railway makes every corner accessible. The gauge is 21½ inches and it can be laid within the standard 4 ft. 8½ in. track, without cutting or notching the rails. Made up in four styles:

Rivetted up track with malleable iron cross ties.

Riveted up steel track.

Knock-down track.

Cast Plate track.

Everything for use with this system is kept in stock for immediate delivery. : : : :

If the necessary data is sent, we will prepare a lay-out without charge and with the right cars will show where this saving can be effected.

No. 008.—Standard Cars. We Design Cars to Meet Any Special Requirements.

C. W. HUNT COMPANY

Established 1872

West New Brighton, New York

New York City, 45 Broadway — Richmond, Va., State Bank Building — Atlanta, Ga., 607 Rhodes Building — Chicago, 1616 Fisher Building — San Francisco, 865 Monadnock Building

Keeping Up the Pace

WHEN, a few years ago, it was found possible, by the introduction of improved steel for cutting tools, to increase very greatly the speed at which machinery operations were performed, it was assumed as a matter of course that great saving in the time required to produce manufactured articles would be the result. This, to a certain extent, proved to be the case, but in many instances the higher speed of actual cutting was found to shorten such a small portion of the entire time as to be of comparatively little advantage.

High-speed steel, however, apart from the influence which it has had upon the speed of cutting metals and upon the designs and construction of the machine tools in which it is used, has acted as a pacemaker for the entire series of operations, of which it forms but a single element. The speeding-up of the line shafting, motors and general machinery of transmission naturally followed upon the introduction of higher speeds on the machines themselves. The reduction in the time during which a piece of work remained in the machine rendered it necessary to introduce appliances for bringing material and removing product, while the general intensification of activity which followed these changes led to further demands for more rapid service.

The term "service" used in this connection indicates in itself the transformation which has taken place in shop methods. Mechanical construction, the realization in metal of the forms indicated upon working drawings, means the removal of superfluous material with accuracy, precision and speed. The men and the machines by whom this is done are the real makers of the article. To them, if they are to maintain the high pace set for them by modern methods and made possible by modern tools, must come such efficient service that the least possible interruption can occur.

The efficiency of the work of the modern machinist forms but one element in the total efficiency of the productive operation, and the final efficiency is not the sum, but the continued product of the several efficiencies of the various elements. This means that if the full advantage of the high efficiency of modern machine tools and methods is to be realized, it must be accompanied with methods and appliances which shall enable an equally efficient service to be maintained. It is of small value to have an efficiency of 80 per cent. at the machine and but 30 per cent. in the service, since it gives a final efficiency of but 24 per cent. for the entire operation. If, on the contrary, we can increase the efficiency of the service to 80 per cent. we have raised the final efficiency to 64 per cent., or more than double the previous figure.

It is the effect which modern cutting tools have had in raising the entire efficiency of a manufacturing establishment which entitles it to be called the pacemaker of the machine shop. In no department has this improvement in pace been more notable than in the appliances for handling the material, in serving the tools and in maintaining the flow. The modern shop contains not only modern tools, rapid and powerful motors and every facility for the rapid conduct of machinery operations; it is also equipped with hoists, trolleys, cranes and handling machinery of maximum efficiency and convenience. The time of a machine operation to-day includes not only the time of performing the work but also the time of putting it in, of taking it out, and of bringing up the next piece, and every moment must be accounted for.

Mechanical Differentiation

THE older text-books on mechanics included, among various arbitrary divisions of the subject, the classification of the so-called elementary machines," these including the lever, screw, wedge, inclined plane, pulley and wheel-and-axle. Modern treatises ignore this time-honored list, or mention it only to point out that the wedge and the inclined plane are practically identical, that the screw is simply the development of an inclined plane upon a cylinder, and that the wheel-and-axle is but a continuous form of lever.

Probably this continuous lever, the modern belt pulley, is better entitled to a place for itself than some other devices which have been suggested, for there is hardly a product of human ingenuity which has so wide an application and so extensive a series of users.

In nearly every other system of mechanical contrivances the element which receives the effort is wholly different from that which is at the sending point. With belt transmission, however, the energy contained in the revolving shaft is passed outward through the continuous leverage of the arms of the pulley to the rim, thus increasing the peripheral velocity many times, and then silently and imperceptibly converting the rotary movement into the linear velocity of the belt or rope it sends it flying across space to a similar pulley, where by a reversal of every operation the receiving shaft takes it up. There is probably no simpler operation in the entire field of mechanics, and yet there is not one which is more useful, more widely applied, and when properly installed, more efficient.

It is in just this last feature, proper installation, that opportunity comes for the work of the transmission engineer. A pulley for belt or rope transmission is not merely a combination of hub, arms and a rim. It must have strength to resist belt-pull, stiffness to resist flexure and vibration, truth of form and of balance, and with these essentials there should be added convenience of installation.

So far as materials are concerned, wood, steel, wrought and cast iron, all have been employed, separately or in combination. The high coefficient of friction between the leather belt and the surface of a wooden rim has made the use of wood advantageous, either with wooden arms or an iron spider, while the lighter weight of the wooden rim is also desirable for high speeds, when centrifugal stresses have to be considered.

Especially desirable for general factory service is it to have line-shaft pulleys made in halves, permitting them to be placed at any desired point on the shaft without disturbing hangers, couplings or other pulleys which may be already in place.

The placing and accurate lining of shafting, a difficult job in itself, is so readily disturbed by uncoupling and replacing a section, that any device which renders this derangement unnecessary is to be welcomed. Since the split pulley, either of wood or of iron, has become a standardized product of manufacture, and especially since the introduction of split bushings has overcome the difficulty of fitting shafts of various diameters, it has been found practicable to install line shafting upon such a permanent system as to render any removal of flange couplings or similar devices wholly unnecessary.

It might have been supposed that there was little opportunity for the improvement of such a simple product as an ordinary pulley, an article which might be sent to the lathe from the foundry, and on to the customer almost without thought. The event has proved, however, that in just such a simple article there was room for skillful design, accurate and refined construction, and the application of inventive talent of a high order.

DODGE

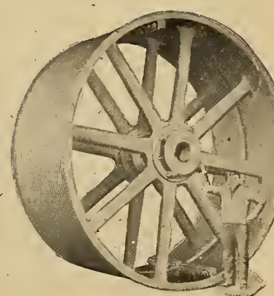
There Are Dodge Pulleys For Every Service

DODGE "Standard" Split Iron Pulley. Non-flexible, and has no riveted joints. Carried in stock with interchangeable bushings. Bulletin C-128.

DODGE Iron Spider Wood Rim Pulley. Bulletin C-18 describes how we safely tested this type of pulley to a rim speed of "5½ Miles Per Minute."

DODGE "Independence" Wood Split Pulley. For 28 years the standard for regular work. Carried in stock everywhere. Bulletin C-77.

We also make regular iron pulleys, flywheels and large special wheels of all kinds. Bulletin C-61 describes our factory facilities and Bulletin C-123 is on "Safe Construction and Speeds for Flywheels."



DODGE Pulleys are profitable pulleys to buy. They are made to give long, efficient service and to do hard work. Please get the bulletins mentioned above. They explain the difference between Dodge Pulleys and—just pulleys. The difference between profit and loss in your pulley investment.

Send a letter or the coupon with 25 cents and we will send you a Dodge Vest-Pocket Slide Rule Calculator, in leather case, for pulleys, belting, friction clutches and shafting. Also bulletins on pulleys. Money back if the calculator isn't a great time and figure saver.

Dodge Manufacturing Co.

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Electric Air a Pneumatic Invention

THERE is at least one curious thing about the development of the electric air channeler, and, in fact of the electric air drill also, in that while the invention as completed and applied is quite revolutionary in its character, and has made the employment of electricity for all kinds of rock-cutting not only possible but highly economical and desirable, there is in the device no improvement of or addition to existing electric apparatus, and we might say, no electric invention is involved.

The electric motor is used in this case with thankfulness for the existence and availability of it, but with no thanks to electric invention for developing its so successful application in this field. This is not the first instance, nor perhaps the largest field, in which pneumatic apparatus has provided employment for electricity as the ultimate motive force. The electric air drill with the electric air channeler now make it possible to employ the electric current as the sole means of power transmission for mine or quarry, and to dispense entirely with large air compressor plants and long pipe lines

It is rare indeed that new inventions develop great advantages and economies without entailing also some partially offsetting objectionable features, and the absence of the latter in the case of the electric air drill has been widely commented on. In fact no sacrifice or even compromise of any desirable working feature has followed, while the saving in power alone is indisputably demonstrated to range up to 60 and 70 per cent. at the power house.

The same characteristics of convenience and economy are emphasized and extended in the application of the electric air principle to the rock channeler. The machine as a whole is much simplified as compared with the steam channeler, or even the air actuated channeler of the older types. Instead of the motor and pulsator separate from the percussion mechanism and requiring to be separately handled with every change of location, these do not require to be moved or looked after at all, being securely and permanently fastened upon the base of the machine and by their weight contributing to its balance and stability. Instead of the two pulsator cylinders with the two cranks to operate them for the electric air drill, there is but one pulsator cylinder and a single crank on the channeler. The one motor serves not only to operate the channeling steels, but also to feed the machine along the track in either direction, and the wires which are the only power connection permit a longer working travel than is ever required in practice. The flexible hose connecting, at each end of each, the pulsator with the channeling cylinder in no way interfere with or limit the possible angular adjustments, so that the channeler is used not only for cuts vertical or nearly so, but also for undercutting at angles approaching the horizontal. The perfect and constant lubrication of the machine was never so well provided for. The same air being used over and over, the oil is not carried away by the exhaust, as there is none, but remains in the machine, and in fact may be considered a part of it to perform its function the same as the piston, the connecting rod or any other essential mechanical member.

The saving of power by the employment of the electric air principle in drill or channeler is so acknowledged and so familiar as to require no mention or explanation. Perhaps the habit of time saving, which also may be claimed for the devices, should be more insisted upon. There is no fixed speed for the ordinary air or steam operated rock drill. It works slower and faster, and when the bit sticks there is nothing doing until the operator does something to free it. The electric air drill or channeler goes along with the rhythm of a military march.

Through the Air

EVERYBODY is interested in aerial navigation at the present time, and no one may venture to predict what to-morrow may bring forth. For to-day, at least, the flying machine is a little more than an object of interest, it is beginning to be an object for comparison with tried and successful mechanical appliances.

The railroad requires a right-of-way and a permanent way as well. The owner of the automobile will never be satisfied until he gets "good roads" over the length and width of the land. The aviator, however, finds his right-of-way open to him, at least until legislation finds some effective method of closing it, and it is only when he has to descend to the surface of the earth that he must choose his path with care. He has, however, one difficulty to contend with, a difficulty not easily overcome, the opposition of adverse winds and strenuous weather conditions. His path is open unless a stronger than he desires to occupy it. The wise aviator stays safely upon the surface of the earth when the weather is unfavorable, while the navigators of the giant dirigibles know too well what the cost of unruly winds has been to them.

Under such conditions, even though the channel has been crossed and re-crossed, and though the frail aeroplane has carried two, three or four passengers for brief distances at high speeds, its availability as a means for the commercial transport of material and merchandise still seems remote.

There is, however, and has been for years in successful use, a method of transport through the air, using a simple and effective system, wholly independent of all kinds of weather. The aerial tramway requires indeed its own line to be constructed between the points it is to serve, but this line, carried through the air, may pass above trees, buildings, fields or rivers; it may traverse rough ground and reach points inaccessible to any surface method of transport.

The freedom from surface obstructions forms an essential element in the effective transport of material between given points. Already the advantages of operating in three dimensions have been discussed in connection with aerial navigation, but in practically all commercial applications it is essential to come to earth at the points of reception and delivery. The aerial tramway does this with positive certainty, and thus adds to the freedom of the air the reliability of the railway. By its use industrial developments have been made possible which would otherwise prove commercially impracticable solely because of transportation difficulties. From the mine to the railway, from the station to the factory, across surface obstacles of all kinds the aerial route has shown itself open.

The applications of devices of this sort have demonstrated the demand for effective means of taking care of the gap which so often exists at the ends of otherwise efficient transportation lines. The great railway can receive merchandise at one terminal and deliver it at another, but the terminal of the railroad is not the terminal of the customer, and there is often a wearisome, tedious and costly haul from the station to the shop. Even when a private railroad siding is available, the question of final handling of material or of merchandise is often a serious one. When, however, it is practicable to install between the terminal of the railway or the siding by the factory a railway through the air to the real terminal of the user, one of the wide gaps in the completion of efficient transport service is bridged, and a considerable saving both in time and money effected, which is one reason why the aerial tramway is being used more largely each year.

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Trade Catalogues

THE modern trade catalogue is an interesting example of the art of the engraver and printer, and it is also, in many cases, the latest and best text-book upon its special subject.

Formerly the manufacturer of a special device or standard machine either depended wholly upon correspondence and the oral representations of salesmen, or else issued some kind of printed matter, with crude illustrations and text which consisted of glittering generalities or extravagant praise, while conveying but little real information to the customer.

To-day the trade catalogue is a product of the best ability which can be secured in all the various departments of the work. The illustrations are made from actual photographs or from special drawings, and are as accurate and explanatory as it is possible to make them. The text is prepared both for the needs of the salesman and for the instruction of the user, and it is the work of engineering specialists who have learned the art of expressing themselves in clear and precise language.

Not only is the particular device under consideration thus given full and detailed publicity; the whole state of the art is often discussed, sometimes with the result of furnishing a more effective engineering treatise than can be purchased from any technical publisher.

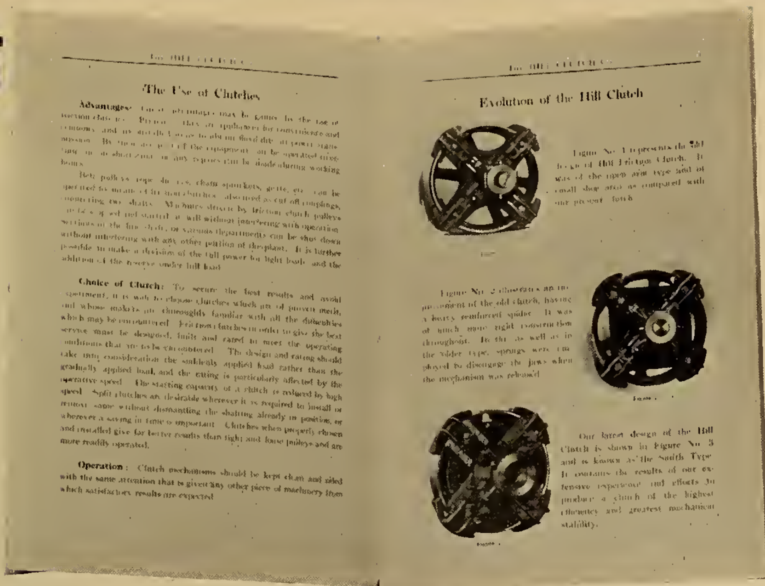
In some cases elaborate scientific tests are conducted at great expense, solely for the purpose of providing data which shall be wholly reliable and enable the facts to be set forth in the catalogue to the best advantage and with undoubted authority. Such tests are frequently made, not by the engineers of the manufacturing concern, however high their standing, but by eminent professional men whose freedom from bias is assured.

Information gathered in this manner is then edited as carefully as the pages of any high-class technical publication, while the material for the illustrations is placed in the hands of engravers who are experienced in this special department of work, and who realize the importance both of accuracy and of effect. Paper, presswork and binding are given similar care and attention and the finished product is, as already said, a high-class treatise upon an engineering specialty.

Under such circumstances it is evident that the product which is placed before the purchasing public with such effort and expense must itself be produced with equal attention. The high-class catalogue is not employed to draw attention to inferior goods, and if it were so used it would defeat its own ends. The full story must be told, and if it does not reveal excellence of design and manufacture the fact will be only too evident. Fulsome praise will not replace fulness of description; general statements only serve to show the lack of detailed information.

Such being the case, it would seem as if the great advance which has been made in trade catalogues during the past decade indicates a corresponding development of the products themselves; and this is, to a great extent, true. Better designs, the result of the work of trained engineers; better and more accurate work, the result of improved tools, methods and systems; better materials, following closely the marvelous developments in metallurgy and investigation: these have all united to improve the product which is so effectively and accurately displayed in the modern catalogue.

The value of the trade catalogue is largely measured by the desire of modern engineers and manufacturers to secure them. When, after such a period of work expenditure and display, the new edition of the catalogue of a prominent house appears, there follows immediately a demand from all sides for copies of the desirable book. Announced in the technical press, distributed freely and widely, it acts at once to educate and sell; it is an investment which pays.



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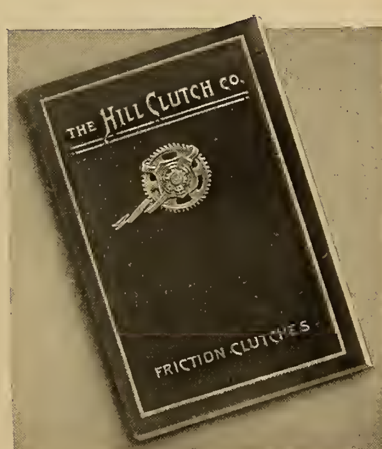

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Concrete Construction

WITH the increasing extent to which concrete has replaced timber and stone for building construction, there has come a number of problems, demanding effective and practical solution in ways which previously did not appear. Some of these questions have been met very effectively; others are yet in course of development.

The preparation of the concrete itself has led to the production of machines for the rapid, economical and complete mixing of the cement, sand and stone, and the result is the great improvement in concrete construction by reason of the more uniform quality of the product and the lower cost in time and money which has followed.

Various developments in the design and construction of moulds for forming and retaining the mixture until it has become fully set have aided in the extending use of concrete as a structural material.

So far as questions relating to reinforcement, by the use of bars of imbedded steel, are concerned, these have been given attention by skilled engineers, with the result that the proper position and dimensions of the reinforcements are well understood, and there is little or no occasion for the errors and defects which naturally accompanied the early efforts with a comparatively untried material. There is one feature, however, which is only beginning to receive the attention which it demands, the question of rendering the mass of concrete wholly and effectively waterproof. While the structure of concrete, when fully completed, resembles a solid mass of natural stone, it must be remembered that it cannot, in its original condition, be assumed to be impervious to moisture. There are few stones found in Nature which are not penetrated by water, and, in fact, the purity of spring water often arises from the fact that it has been filtered through natural layers of rock and similar material. When, therefore, the artificial stone which a hardened mass of concrete really becomes, is exposed to the influence of moisture, it is only natural to expect that it will behave in a similar manner to the material from which it is composed.

Two methods may be considered in the imparting to concrete of the property of resisting moisture; there may be an external coating of some waterproofing material applied to the surface of the finished work; or advantage may be taken of the access to the interior of the mass which is given during construction, and the waterproofing substance incorporated with the elements of the concrete. Each method has its appropriate applications, and both are capable of extensive uses. The essential point is that the question of waterproofing should be taken up while the structure is in progress, or, at least, before it is so covered and trimmed that access to all parts has become impracticable. Like all other questions connected with the successful use of concrete, the subject of waterproofing should be entrusted to specialists who have studied the best methods and know the results which may be obtained under given conditions.

The importance of proper and complete waterproofing can hardly be overrated. For residences, freedom from dampness is essential to health and comfort, and a damp concrete house is a structure which, in the light of present knowledge, has no right to exist. For buildings in which perishable materials, such as grain and other foodstuffs or any material affected by damp, are stored, effective waterproofing is a condition which must be positively assured or the work will be a failure.

In the light of present knowledge, there is no reason why the problem of the prevention of dampness in concrete structures may not be considered as wholly solved, and the only necessity lies in its full consideration at the proper moment.